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ANALYSIS OF TYPED THREE-LETTER COMBINATIONS AS SEPARATE WORDS AND AS PART OF LONGER WORDS

by

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Analysis of Typed Three-Letter Combinations As Separate Words and As Part of Longer Words," submitted by George Arthur Garbutt in partial fulfillment of the requirements for the degree of Master of Education.

ABSTRACT

The purpose of this study was to examine whether, in certain situations, three-letter combinations of typewriting strokes are made at a "stroke response" level (stroke by stroke), or at a "word response" level (two or more strokes typed as a unit). The most common three-letter word, "the," was used for the study, and parallel series of tests, using the second most common three-letter word, "and," were conducted for verification.

Forty second-year typewriting students typed special copy which contained: "the" as a separate word; other three-letter words; English-language words containing "the" as part of the word; and matched "nonsense words" containing "the" as part of the word. As the students typed, electrical switches connected to the typewriter caused an oscillograph pen to trace a graphic record of the time intervals between strokes. The paper, on which the pen traced, moved at a constant speed and the distance between strokes could be measured to a precision of approximately 1/920th of a second. Variations in times for typing "the" in different contexts were statistically analyzed, using these numerical measurements of stroke times.

The conclusions from the study were: (1) Word response typing does exist in the typing of three-letter combinations. (2) The time required to type a frequently-typed three-letter

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combination is less than the time required for a less-frequently-typed combination. (3) Results are inconclusive when comparing times for typing a three-letter word and typing the same strokes when they appear as part of longer words, although the weight of evidence indicates that less time is usually required for typing the strokes when they appear as a separate word. (4) The apparent saving of time, arising from the transition from stroke response to word response typing, is not large in comparison to the size of moment-to-moment variations for a typist, or to the size of variations between individuals who are typing at the same gross speed.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation for the generosity and interest of Messrs. Peter Savage and Jim Grover of Canadian Magnetic Reduction Ltd., who loaned the recording apparatus used in this study and also guided and assisted with the instrumentation and measurement procedures.

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TABLE OF CONTENTS

PAGE

LIST OF TABLES

TABLE PAGE

[illegible]

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

INTRODUCTION

NEED FOR THE STUDY

During the first hours of learning to typewrite, a student consciously types just one stroke at a time, which typewriting text books term "stroke response" typing. Soon, however, some short words which are met frequently appear to be typed as one grouped unit, rather than as a series of consciously-typed strokes. Text books refer to this as "word response" typing. While few experienced typists would deny that something of this nature does develop, the basis for their belief is primarily subjective, and the objective evidence to prove the existence of "word response" typing is not conclusive. Among a multitude of questions which arise in thinking of this transition from "stroke response" to "word response" typing, clarification is needed especially concerning how "word response" typing develops, when it develops, and how much improvement is possible. If more information could be obtained about the development of "word response" typing, it could lead to changes in instructional methods which might shorten the instructional period.

There is a further need in typewriting for timed studies which, for close analysis, divide the operation into its smallest elements. Ordinary visual or auditory observation is not precise

enough to discern what is happening when several complete strokes are made per second, and thus slow or inefficient operation could well continue without being noticed or corrected. Finely timed records of a typist's performance might show the weak points of technique, and enable corrective practice to commence. To recognize what constitutes a good or a weak performance of certain typing techniques involves learning what is normally done by typists of similar speed or experience. Finely timed records would help in establishing normative standards, to be used as a basis for analysis.

PURPOSE OF THE STUDY

It is the purpose of this study to use physical timings of the intervals between typewriting strokes as objective evidence to indicate (1) whether "word response" typing does exist; (2) whether "word response" typing is related to the frequency of typing the word; and (3) whether a three-letter group of strokes which is typed in a "word response" pattern when typed as a separate word continues to be typed in a "word response" pattern when it occurs as part of a longer word, or in an unfamiliar setting.

HYPOTHESES

In line with the preceding purposes, the following hypotheses were formulated, for testing:

I. There is no significant difference between the time required for the typing of frequently-typed three-letter combinations when they appear in actual frequently-typed words, and when they appear in non-English-language words of similar stroking patterns.

II. There is no significant difference between the time required for the typing of frequently-typed three-letter combinations and three-letter combinations of similar stroking patterns which are less frequently typed.

III. There is no significant difference between the time required to type common three-letter combinations occurring as separate words, and the time required to type the same combinations occurring in longer words.

ASSUMPTIONS

This study assumes that:

1. Typing students late in their second year of instruction will have had sufficient experience to develop "word response" typing patterns on the three-letter combinations used for analysis.
2. Typing students late in their second year of instruction will have practiced on a broad enough range of materials that the frequency of encountering different words will be roughly parallel to the frequency of meeting those words in business communications.

LIMITATIONS

1. This study deals with stroking patterns at a specified stage of speed development, and accuracy of typing has not been considered. However, if errors are made, some sections of the information cannot be used.
2. The two short words used for analysis in this study are the most common three-letter words, and are of a specified stroking pattern.
3. The methods of typewriting instruction are not considered.
4. Reading factors, such as the way in which typists read the copy, or how they perceive different letters, groups of letters, syllables, words, or groups of words, are not considered.
5. Cognitive factors, such as the way typists' performances might be affected by their understanding of the language used in the copy material, are not considered.

DEFINITION OF TERMS

Stroke Response Typing. The process of typing in which the typist is aware of each stroke as a separate physical process, distinct from the strokes preceding or following it.

Word Response Typing. The process of typing in which two or more consecutive strokes are typed as a unit, without the typist being aware of the separate strokes comprising the unit.

Time for a Stroke. The interval of time between the graphic recording of one typing stroke and a second typing stroke is

considered as the time for the second of the two strokes. For example, using the word "but": the interval of time from the recording of "b" to the recording of "u" is considered as the time for the stroke "u."

Units of Time. The finest graduations on a specially-constructed measurement scale with which the graphic recordings of strokes were measured. Each unit of time is approximately 1/920th of a second.

Frequency of a Word. The relative frequency with which a word appears in business communications, as specified in Silverthorn's list.[1]

Stroking Pattern. A sequence of typewriting strokes, differing from other such sequences by the order in which left-hand and right-hand strokes are made.

Similar Stroking Pattern. A sequence of typing strokes in the same succession of right- and left-hand movements, or, ideally, strokes in the exact sequence of finger use. e.g., the words "her" and "hat" both have an "h" struck with the right hand, followed by two strokes made with the left hand. The words "sore" and "word" have an exact sequence of finger use -- both have their first strokes made with the third finger of the left hand, have the identical second and third strokes, and have their fourth strokes made by the second finger of the left hand.

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[1]J. E. Silverthorn, Word Division Manual (Cincinnati: South-Western Publishing Company, 1958), pp. 85-109.

Alternate-Hand Stroking. A sequence of typing strokes in which the hand used changes for each successive letter stroke. e.g. the word "worm" is typed by the left hand for "w," right hand for "o," left hand for "r," and right hand for "m."

Opposite-Hand Stroking. The same as Alternate-Hand Stroking.

Nonsense Words. Combinations of letters which do not constitute an English-language word.

Gross Speed of Typing. The total number of typing strokes, divided by five to obtain a standard length of "word," and further divided by the typing time in minutes, without deduction for errors. The gross speed is expressed in "words per minute," which is abbreviated to "w.p.m."

Syllabic Intensity. The total number of syllables divided by the number of actual words in a passage of written material. It is often used as one measure of difficulty of written material being used for typewriting copy. e.g. "The interval of time" has six syllables in four words, giving a Syllabic Intensity of 1.5.

Recording Apparatus. The physical equipment used in making a graphic record of the moment of occurrence of each of a series of typewriting strokes. It consists of: micro-switches for completing electrical connections, attached to a typewriter; wiring linking the micro-switches to an oscillograph; a recording oscillograph which traces by means of an inked pen a graphic record on chart paper, as electrical impulses are transmitted and interrupted.

Typewriting 20. The second year of typewriting instruction in senior high schools in the Province of Alberta, Canada, as prescribed in the Curriculum Guide.[2]

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[2]Alberta Senior High School Curriculum Guide for Business Education (Edmonton, Alberta: Department of Education, Province of Alberta, Canada, September, 1960), p. 31.

CHAPTER II

REVIEW OF THE LITERATURE

GRAPHIC RECORDING OF TYPEWRITING

Since 1943 no typewriting study using graphic recording has been discovered, even though considerable use was made of this tool prior to that time. It appears to have been a relatively unimportant tool in recent years.

Bryan and Harter[1] pioneered research in the field of perceptual motor learning in their studies of telegraphic sending and receiving. In telegraphy a series of dots and dashes make up individual letters, with pauses between letter-groups to make up words, and pauses between successive words. In a five-letter word there might be fifteen or eighteen strokes to sort out according to their letter and whole word patterns. Bryan and Harter tested trainee and experienced telegraph operators on receiving of letters which did not make up words, words which did not make sentences, and words connected in meaningful material. Their experiments, using physical measurements to about 1/100th of a second, showed that words could be received faster than letters at random, and also that words connected in a sentence could be received faster than unconnected words. No figures as to the sizes of difference were reported.

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[1]W. L. Bryan and N. Harter, "Studies in the Physiology and Psychology of the Telegraphic Language," Psychological Review, Vol. IV (1897), pp. 27-53.

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They found, also, that operators develop different methods of patterning the groups of strokes, so that each skilled operator's sending of telegraph material was distinctive enough that the receiving operator could identify the sender. Repeated recordings on a moving drum confirmed these patterns. In addition it was shown that the patterning changed somewhat at different speeds, and that higher speeds were attained by shortening some of the longer characters. Operators reported they did not intend to make every dot identical, but would vary them in different situations, like the inflections of speech. The graphical recordings confirmed this variation.

Book[2] in his studies prior to 1908 used typists' introspective reports, with visual checks on behavior by an observer, and further verification by recordings on a kymograph. The records on the kymograph drum supplemented what the typist and observer thought or noticed, and also suggested further questions for analysis and observation in later practice sessions. Book used eleven subjects; of these only six learned the "touch method" of typing, while the others used a "sight method," where they looked back and forth from the copy to the machine.

Book's recording apparatus grouped the strokes too closely to permit finely-timed measurements of any real accuracy. The

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[2]William F. Book, The Psychology of Skill (New York: Gregg Publishing Company, 1925).

closeness, however, did allow the grouping of strokes to be visible more easily than if the strokes were widely dispersed along the record. The straggling letter-by-letter portions of the typing stood out fairly clearly, while groupings of familiar or easy material also could be seen at a glance.

Book claimed that good typists got to the point where they not only put a whole word into one unconscious pattern, but actually grouped two, three, or even more common words into a pattern for a whole phrase.[3] He did find great variations within individuals on different days, or even from minute to minute. There were some occasions when successive minutes had a third more typing than the previous minute, with no single trouble spot to account for the large variation.[4]

Lahy[5] did graphic recording of professional typists in France between 1912 and 1921. His most striking finding was that alternate-hand strokes can be made approximately twice as fast as stroke sequences made by the same hand. This was highlighted by a simple tapping test, using the first finger of one hand, then the first finger of the other hand. These were followed by a tapping test, alternating the first fingers, and the rate was about twice as

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[3] _Ibid._, pp. 115-118.

[4] _Ibid._, p. 164.

[5] J. M. Lahy, "Motion Studies in Typewriting: A Record of Experiments," _International Labour Office, Studies and Reports, Series J (Education)_, No. 3, (Geneva, Switzerland: International Labour Office, 1924).

fast. The same thing seemed to hold true with word copy, using alternating-hand material, then left-hand material, followed by right-hand material.

The Gilbreths[6] did time and motion studies on typewriting, using high-speed motion pictures, with a timing mechanism which showed differences of about 1/277th of a second. These films showed clearly that typing at slow speeds was a very different operation, in its physical patterns of finger movement, from typing at high speeds by the same typist. When typing fast, the typist had to begin preparing for the next stroke before completing the preceding stroke. When the two strokes were on opposite hands, while a finger on one hand was in contact with its key, the finger on the other hand would be visibly raised, and perhaps even starting its downward movement.[7] This interlocking of movement, this pre-positioning for the next stroke, would be a fundamental part of word-response typing, if such exists.

Coover[8] did timings to about 1/1,000th of a second on expert typists who were typing approximately 130 words per minute. He measured and analyzed their speeds on differing finger combinations

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[6]Frank M. Gilbreth and Lillian M. Gilbreth, Applied Motion Study (New York: The Macmillan Company, 1919).

[7]*Ibid.*, pp. 36-37.

[8]J. E. Coover, "A Method of Teaching Typewriting Based on a Psychological Analysis of Expert Typing," Proceedings (National Education Association, 1923), pp. 561-567.

of adjacent pairs of strokes, which he termed "digraphs." He found that stroking sequences moving from one hand to the opposite hand could be typed about 145 words per minute. Sequences of two successive strokes with the same hand, but moving from one finger to another, could be typed between 115 and 122 words per minute. Sequences in which two keys in a row were struck by the same finger could only be typed between 70 and 85 words per minute.

Coover also found that in typing a familiar phrase, "this is the," which combines opposite-hand sequences and the familiarity of frequent practice, the average speed worked out to 174 words per minute, more than twice the speed for simply tapping one stroke repeatedly. He concluded that for high speed in typewriting, some form of grouping or "patterning" of letter sequences, words, and perhaps even of phrases would be a necessity to overcome the relatively slow "tapping rate," where the successive strokes are made by the same fingers. Coover stated that the tapping rate is "a fundamental physiological performance that does not increase materially with practice." From this he concluded that the champion "gains this expertness by improving the other sequence-techniques, especially the reach and opposite sequences."[9]

Butsch[10] recorded measurements on ordinary key strokes,

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[9] Ibid., p. 563.

[10] R. L. C. Butsch, "An Experimental Study of Progress in Typewriting," Unpublished Master of Arts Thesis, (University of Chicago, 1927).

space bar strokes, capital letter strokes, and carriage return operations. His study highlighted the great variations there are in typists' performances. As expected, speeds on the ordinary key strokes varied widely within classes, but there seemed to be no consistent relationship for the space bar stroke, capital letter stroke, or carriage return operation, when compared to the key strokes. For example, the fastest typist in a room might have the fastest basic key strokes, but might be among the slowest on capital letter strokes. Median results, from a very dispersed group of scores, were: for the space bar stroke, approximately .80 of the time taken for an ordinary stroke; for the capital letter stroke, including shift key use, striking of the key, and release of the shift key, 2.99 times as long as an ordinary stroke; and for the carriage return operation 7.03 times as long as an ordinary stroke.

Odell[11] tested two expert typists, using a measuring device on which the key strokes were made directly on a moving strip of paper underneath the typewriter ribbon. He examined the results for apparent rhythm of typing and for the patterns of typing certain words and, from an admittedly incomplete study, gave the following tentative findings:

> (1) There is a general tendency for expert typists to use a <u>pattern</u> in successive writings of any given

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[11] William R. Odell, "Rhythm and Patternism in Typewriting," <u>Business Education World</u>, XIX (1939), pp. 537-540.

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word. In scarcely a single instance do these patterns conform to the traditional concept of rhythmic writing as defined above -- that is, an even interval between successive strokes. . . For example, the word art in general is written almost always with a and r closer than r and t . . . This was true of material in context as well as when the isolated word was written.

(2) The conclusion is that with certain words, the context in which the word is written seems to exert a considerable influence upon the pattern that is used for writing it. For example, in the word towns, in a paragraph in which the word occurred six times in context, the pattern for the writing of towns varied considerably. This probably is due to the fact that what precedes or follows afford countless opportunities for other combinations to be used. In a certain sense this second finding conflicts with the first one reported.

(3) Different expert typists may or may not write the same words with the same patternism. For example, George Hossfield and Harold Smith used practically identical patterns for the word crucifixion, although they used a distinctly different pattern for the word spontaneous.

Odell suggested further that there was reason to believe that the machine might be useful for suggesting how many successive times a word should be written at one practice, how to practice a word, whether in or out of sequence, and other questions.

Six years later this study was mentioned as still being incomplete,[12] and no record was located of a final report of these experiments being published.

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[12]W. R. Odell and E. R. Stuart, Principles and Techniques for Directing the Learning of Typewriting, Second Edition (D. C. Heath and Company, 1945), p. 221.

McMillon[13] developed an apparatus which he described as inexpensive and easy to operate, with which he could record the period of time a finger remained on a key, the time between the key strokes, the time the hand remained on the carriage return lever, and the time a finger remained on the shift key for capital-letter strokes. He constructed a working model and suggested possible uses for it as a classroom tool, but in his thesis proved only that the apparatus would work and do what was intended for it.

Later, at a U.S. Navy training center Vandegrift and McMillon[14] tried out McMillon's apparatus in classroom applications. It could be moved from class to class, and attached fairly readily to any make of typewriter, and was used by both the teacher and the student for diagnosis of weak and strong points in the student's performance. The researchers visualized "innumerable ways in which a simple recording device, of the type described here, can be used for the benefit of both teacher and learner in the typewriting classroom." Minor faults in typing technique are usually unnoticed by the student, and in a large class it is unlikely that the teacher will notice all such faults. Even if alerted to some

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[13]Roy W. McMillon, "A Mechanical Device for the Graphic Measurement of Certain Techniques in Typewriting," Unpublished Master of Science Thesis, 1942, Oklahoma Agricultural and Mechanical College.

[14]J. R. Vandegrift and Roy McMillon, "Recent Research in Graphic Time Studies in Typewriting," National Business Education Quarterly, December, 1943, pp. 5-8, 49, 67.

problem, careful visual observation of the student's typing may not reveal what is happening, simply because the motions are too small in scale and too close in time. With this recording device, the students took recordings of their own typing, looked them over for clues to trouble, and consulted with the teacher. The recordings were used regularly to measure the progress of each student, and to highlight those words or techniques which gave trouble to that student. The words or techniques could then be practiced, with guidance from the teacher. Motivation in competing against their own previous performance was very high.

Vandegrift and McMillon found that even experienced typists could improve performance by isolating the places where faulty operations were weakening their total performance. They mentioned one girl who raised her gross speed from 60 to 75 words per minute after one type of error was isolated and then corrected with practice drills.

With their classes, they confirmed the findings of Coover[15] concerning speed of opposite-hand and same-hand sequences, and they found that highest speeds were attained on common two- and three-letter words. They found capital letters required the equivalent time for three ordinary strokes, which agreed with Butsch.[16] They

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[15]Coover, loc. cit.

[16]Butsch, loc. cit.

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found the carriage return required the equivalent time for six ordinary strokes, one less than Butsch had reported.

They reported that graphs which seemed to be typical of the group led to the following observations:

> 1. Word and Letter Level Typing. Are there only two levels of typing skill? Do we always type on one of these two levels?
>
> Experiments in WAVES classes at Oklahoma A. and M. College indicate that all students type on both levels at every writing; that is, certain words have become automatic and are typed as a multiple response to one stimulus, and other words are typed with as many stimuli and responses as there are letters in the word.
>
> 2. Word Patternism. Normal "rhythm" patterns of various words are affected by two factors: (1) arrangement of the keyboard, and (2) the degree of automatization of letter combinations within the word. The word "brother" will serve to illustrate this with the hyphens indicating the lapses: b-r-other, b-r-o-the-r, br-o-t-he-r, and b-r-o-t-her. These samples were all taken from performance records. The time value represented by the hyphen varies; time losses between strokes are unequal.
>
> 3. Word Speed. Graphic records disclose that each word has a distinct speed level at which it is usually executed. These factors influence the speed: (1) The degree of automatization, usually correlating to a fairly high degree with the frequency of the word. (2) Keys used in executing the word. (3) The hand used in typing the word. (4) The degree of automatization of sequences within the word.[17]

A question must be raised here concerning these findings. Vandegrift and McMillon do not mention the scale of the graphic recordings, but in McMillon's description of his original working

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[17]Vandegrift and McMillon, op. cit., p. 49.

model,[18] he mentioned a paper speed of 13.33 millimetres per second. Since five or six strokes might occur in one second, each stroke would be separated by two to three millimetres, and fractional readings of millimetres would be necessary to detect any but the grossest variations in speed of stroking different sequences. Reading such measurements accurately would be difficult. It is, of course, possible to change gearing for a faster paper speed, and consequently obtain greater separation between strokes. They also did not mention how measurement was done, and a lingering question remains as to how much time was required for measurement of each record produced, and whether a practical amount of value was obtained for the time spent in the measurement. Butsch's study also aroused similar questions.[19]

Vandegrift and McMillon were attempting also to find a method for assigning a "word index" figure to different words. This "word index" would indicate the ratio with which the word was typed, as compared to the typist's over-all typing speed. If a typist's over-all speed was 50 w.p.m. and a certain word was typed at 75 w.p.m., the word index for that word for that typist would be 1.5. Presumably "norms" for experienced typists could be developed, and a typist would be alerted to look for the cause if

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[18] McMillon, loc. cit.

[19] Butsch, loc. cit.

his performance was much below the expected "norm." On one simple paragraph but with only ten typists, they arrived at a word index of 1.35 for the word "the," and 1.29 for "and." Some two-letter words were faster, 1.50 being the highest. They also hoped to be able to build up a "job efficiency index," a ratio of stroking rate compared to production rate of, say, letters produced.

Unfortunately, no later reports of results of these studies by Vandegrift and McMillon were published. Correspondence with Oklahoma Agricultural and Mechanical College did not locate any more information as to whether their studies were continued or completed.[20]

INTROSPECTIVE STUDIES OF TYPEWRITING SKILL

Many of the early studies of typewriting used introspective reports and analysis as tools of investigation.

Bryan and Harter used introspection in their first study,[21] and again, on a larger scale, in a follow-up study.[22] They dealt with telegraphic operators at all levels of skill, who reported that at first they had to "hustle for the letters." Later the

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[20]Letter to Business Education Department, Oklahoma A. & M. College, Stillwater, Oklahoma, July 18, 1964, and reply from Dr. Robert A. Lowry, Head, Department of Business Education, July 21, 1964.

[21]W. L. Bryan and N. Harter, "Studies in the Physiology and Psychology of the Telegraphic Language," Psycholomgical Review, IV (1897), pp. 27-53.

[22]W. L. Bryan and N. Harter, "Studies on the Telegraphic Language. The Acquisition of a Hierarchy of Habits," Psychological Review, Vi (1899), pp. 345-375.

learners were able to "go after the words," but when they became good operators they could take in several words at a time, a phrase or perhaps even a sentence, with practically no attention to the details of the letters as they came in.[23] Cipher messages, which were not meaningful, were reported as being harder to send and to receive.

Book[24] used introspection as a major tool, supplemented by an observer, and with graphic recording as a further aid. More than half his subjects were trained in psychological methods, which at that period stressed introspective analysis. The subjects would write down their comments, as thoughts occurred to them, would review their feelings for the day at the conclusion of their practice period, often using a check list, and would answer any questions which occurred to the observer as he watched them at practice.

These introspective reports led Book to outline five separate steps being taken by the typist in making each typing stroke in the earliest days of practice. These separate steps were reported as merging, until the "motor tactual image" gradually disappeared from consciousness over a period of several weeks. Soon the typists began to report reading syllables and short words as units, rather than letter by letter, and these began to be typed as units, as well as being read by units. Book termed this "group

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[23]*Ibid*., p. 352.

[24]William F. Book, *The Psychology of Skill*. (New York: Gregg Publishing Company, 1925).

spelling." His typists reported feeling quite sure the next several keys could be hit correctly, but would be unaware consciously just where the fingers were until suddenly trouble arose. At a time of trouble they would become aware of the separate movements just completed, and of the movements to follow immediately afterward.

Book cautioned, as others have since, that an expert might in a short period type at stroke level, syllable level, word level, or phrase level, depending on the difficulty, familiarity, or length of the words encountered.[25]

The dangers of introspection come to light here, since Book's subjects felt that in the expert stage they were reading the copy four or five words ahead of where they were typing, which permitted them to see awkward combinations and prepare to meet them. Later, photographs of eye movements during typewriting, by Butsch[26] and Fuller,[27] showed that even champions seldom read farther ahead than what they will type in the next second. For typists at 60 gross words per minute this would be only five strokes ahead, or approximately one word.

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[25] Ibid., p. 48.

[26] R. L. C. Butsch, "Eye Movements and the Eye-Hand Span in Typewriting," Journal of Educational Psychology, February, 1932, p. 113.

[27] D. C. Fuller, Reading Factors in Typewriting (Stillwater, Oklahoma: Oklahoma A. and M. College, 1945), 112 pp.

The Gilbreths,[28] in their series of time and motion studies of different activities, used personal observations, high-speed photography and timing, but also did aggressive questioning of their subjects. Dvorak[28] cites their questioning of a Speed Coach and a Speed Typist, and concluding that "this typist pays no attention to her hands. Her hands have been educated to obey the impulse not in fingers, but in words and phrases."

Swift[29] made an introspective report on his experiences while learning to type. He reported that:

> I found myself writing easily on the twenty-fifth day, so easily that I came near relaxing overmuch. Although keyboard locations were not yet automatic, common, short words like "the," "is," and "an" seemed to lose their letters and become words . . . . By the twenty-ninth day, stroking by the motion feel was improving. Up to that time the only words that could be said to be responded to as words, instead of as words composed of certain letters, were still "the," "an," "of," and "is."
>
> (By the thirty-second day): . . . Even in short common words letters constantly tended to obtrude.
>
> By the thirty-sixth day, I was writing more by words than at any previous time. Unquestionably two days later word writing was more frequent. Yet any little difficulty caused me to drop into letter writing, even after I seemed to start on the word as wholes . . . . On the forty-first day, the writing was clearly increasing. Words were written at once without any awareness of the letters.

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[28]F. W. Gilbreth and Lillian M. Gilbreth, "Gilbreth Motion Study Notes," cited by A. Dvorak, N. L. Merrick, W. L. Dealey, and G. C. Ford, Typewriting Behavior, (New York: American Book Company, 1936), pp. 160-61.

[29]E. J. Swift, "The Acquisition of Skill in Typewriting," Psychological Bulletin, Vol. I (1904), pp. 295-305.

Towne[30] made a similar introspective report that:

> The first group of small words had been written automatically about the fortieth day. Letters, syllables, words, and groups of words began dropping into the background. By the end of the sixtieth day, short familiar words, such as "and," "the," "we," caused no trouble at all.

REFERENCES TO "WORD RESPONSE" AND "STROKE RESPONSE" IN INSTRUCTIONAL MATERIALS

References to "stroke response" or "word response" typing do appear in certain books directed to teachers of typewriting, but the terms used are not identical.

Book[31] spoke of letter-level, syllable-level, word-level, and phrase-level associations. He also spoke of lower-order skills, in referring to typing one letter at a time, and higher-order skills as the typist progressed to the syllable, word, or phrase level.[32]

Blackstone and Smith[33] tied the idea of "word-response" typing to the word "automatization," saying:

> The idea of automatization . . . involves the concept that common words and syllables shall have become so well

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30Blanche M. Towne, "An Individual Curve of Learning: A Study in Typewriting," Journal of Experimental Psychology, Vol. V (1922), pp. 79-92, cited by A. Dvorak, N. L. Merrick, W. L. Dealey, and G. C. Ford, in Typewriting Behavior (New York: American Book Company, 1936), p. 428.

31William F. Book, The Psychology of Skill (New York: Gregg Publishing Company, 1925), pp. 44-5.

32Ibid., p. 121.

33E. G. Blackstone and S. L. Smith, Improvement of Instruction in Typewriting (New York: Prentice-Hall Inc., 1946), p. 163.

> known that the entire syllable, word, or phrase may be typed by a sort of serial reaction in which no conscious thought is required.

West[34] uses the terms "lower-order habits" and "higher-order habits" as well as the idea of a serial reaction. He says, "Typewriting may also be described as a <u>serial response task</u> since the higher stages of skill consist of handling series of movements in chained fashion." However, he cautions that:

> Such labels as "syllable-level," "word-level," and "phrase-level" typing for the various orders of habits represent misleading approximations. Possibly more often than not, the sequences typed under high-order habits do not correspond with the linguistic units contained in the conventional labels. It would clear the air and preclude many misconceptions if these conventional labels were dropped completely and we used, instead, simply 1-stroke, 2-stroke, 3-, 4-, 5-stroke (and so on) habits as names for the levels in the hierarchy. Or, letter-level typing may properly be retained as a description for the lowest order of habits, followed by letter-sequence or, more simply, sequence habits.

West cites an experiment by Fendrick[35] in which typists from beginner to expert typed an ordinary passage of sentence material and also another passage made up of the same words but in non-sentence order. The gains in speed from having the material in regular sentence order were very small, not over four per cent for any level of typing ability. It would seem from this that "phrase-level" typing is almost non-existent. Experiments on

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[34] L. G. West, "The Teaching of Typewriting," (Mimeographed, 1956), Chapter 3, pp. 3, 4, 35.

[35] Paul Fendrick, "Hierarchical Skills in Typewriting," <u>Journal of Educational Psychology</u>, Vol. XXVIII (1937), pp. 609-620.

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reading of typewriting copy by Butsch[36] and Fuller[37] would seem to confirm this, for they found that typists seldom read more than a very few letters ahead of where their fingers are striking the keys.

Fendrick's experiment also showed that there was very little gain in speed in typing copy made up of easy words, over typing copy made up of words of medium difficulty. The slower typists actually typed the "Medium Prose Word" copy faster than the "Easy Prose Word" copy. Expert typists typed the Easy Prose Word copy slightly faster, but the highest gain was only five per cent. West concluded:

> The notion of "word-level" typing is thereby called into serious question. The evidence suggests that the hierarchy of stroking habits does not extend much beyond the letter-combination level. It is probable that when entire words are indeed mastered, they are limited to the very short and easily fingered ones.[38]

Jane Clem[39] expresses some contradictory ideas. She says that the word-habit process may be extended to whole sentences, and even to paragraphs, if the typists were experts and the sentences were familiar ones. She says, "The thought of the sentence sets up

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[36] R. L. C. Butsch, "Eye Movements and the Eye-Hand Span in Typewriting," Journal of Educational Psychology, February, 1932, p. 113.

[37] D. C. Fuller, Reading Factors in Typewriting, (Stillwater, Oklahoma: Oklahoma A. and M. College, 1945), p. 97.

[38] West, op. cit., Chapter 3, p. 10.

[39] Jane Clem, Techniques of Teaching Typewriting, Second Edition (New York: Gregg Publishing Division, McGraw-Hill Book Company Inc., 1955), 380 pp.

the flow of motions necessary for its writing."[40]

Concerning instruction of students, she says:

> . . . . These word habits start early and are built up by degrees . . . . The student begins with short, familiar and frequent words, and then progresses to longer, less frequent words or phrases.
>
> The teaching process should attempt to parallel this learning process . . . . When the time seems proper, the teacher should encourage the students to write the most common two-stroke words without conscious thought; that is, think the word and think nothing further, leaving the mind a blank until the fingers have finished. Then, longer words, until the process is extended to as large a vocabulary as possible.[41]

But later she says:

> But there is as yet no recognized way of identifying the moment when the typist departs from the isolated-stroking level and advances to the combination level.[42]

This does not give a classroom teacher much help in deciding "when the time seems proper," for trying to assist the word-habit process to develop.

The two typewriting text books approved for use in Typewriting 10 and 20 classes in Alberta differ strongly in the emphasis they give to word response typing.

One book attempts to help the student advance to word-habit patterns.[43] As early as Lesson 12, which is to be taught approximately the end of the third week, the student is told:

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[40]Ibid., p. 71 [41]Ibid. [42]Ibid., p. 221.

[43]D. D. Lessenberry, T. J. Crawford, L. W. Erickson, and P. A. Monkman, 20th Century Typewriting, Complete Course, Canadian Edition (Scarborough, Ontario: W. J. Gage Limited), 338 pp.

> <u>How to Read the Copy</u>. You have been typing much of your work by <u>stroke</u> (or letter) <u>response</u>. You type by this response when you see, think, and type letter by letter.
>
> In typing short, simple words, <u>think the word</u>, not the letters. This will help you to type by <u>word-recognition response</u>. For example, instead of thinking and typing <u>o r</u>, think the word <u>or</u>. The right sequence of letters will be noted by your eyes without conscious effort on your part, after you have typed by word-recognition response.[44]

The copy which followed these instructions consisted of three lines of short, common words, mostly of two or three letters. Curiously, the Teacher's Manual for this book[45] makes no mention of this topic at this point. The first reference in the Teacher's Manual seems to be with instructions concerning Lessons 26 to 30, which are to be taught about the seventh or eighth weeks. The authors suggest the teacher have the students drop back to Lesson 25 for repetition of single-syllable words, and state: "The return to copy with nothing but one-syllable words will quickly lead into rapid stroking and to word-recognition response."

There are at least nine additional sets of instructions to the students, urging and helping them toward word-recognition response, spaced through textbook Lessons 1 to 75.[46] In Alberta

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[44] <u>Ibid</u>., p. 41.

[45] D. D. Lessenberry, T. J. Crawford, L. W. Erickson, and P. A. Monkman, <u>Manual for Textbook, Workbook, Tests, with 20th Century Typewriting</u>, Complete Course, Canadian Edition, (Scarborough, Ontario: W. J. Gage Limited), p. 19.

[46] Lessenberry et al., <u>op. cit</u>., pp. 20, 24, 29, 38, 45, 52, 62, 74, 102.

these lessons are covered in the first year.[47] For the early part of the second course there are a few references in the text book to this topic, including one reference to "word, stroke, and syllable response."[48] There is no mention of the subject after Lesson 100, even though there are 75 lessons remaining in the second-year's work. Practice materials accompanying the instructions give words as high as five letters in length, and one lesson marks two or three words into separate groups, instructing the student to ". . . try to read and type as a group the words given between the vertical lines. In order to do this, you will need to keep your eyes on the copy and think the words as they are typed."[49]

In the Canadian edition of another text book, used by all the subjects in this study, nothing is mentioned to the student about "word response" or "stroke response" typing.[50] There is no Teacher's Manual for this text book. Another Teacher's Manual for an American text by the same authors was examined,[51] and no

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[47] Alberta Senior High School Curriculum Guide for Business Education (Edmonton, Alberta: Department of Education, Province of Alberta, Canada, September, 1960), p. 30.

[48] Lessenberry et al., op. cit., p. 113. [49] Ibid., p. 142.

[50] J. L. Rowe and A. C. Lloyd, Gregg Typing, Second Edition, Complete Course (Toronto: Gregg Publishing Division, McGraw-Hill Book Company, Inc., 1958), 357 pp.

[51] J. L. Rowe and A. C. Lloyd, Teacher's Manual for Gregg Typing, New Series (New York: Gregg Publishing Division, McGraw-Hill Book Company, Inc., 1954), 80 pp.

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direct references were found to the subject. They do speak, however, of constructing practice materials with an eye to difficulty of the copy, and also stress that "the book contains more drills that encourage, sustain, and renew typing accuracy than have ever before appeared in a textbook." They then list many types of drills, including "Word-family drills," "Same-prefix drills," "Same-suffix drills," and "Root words and derivative drills."[52] These drills are present in the Canadian edition of the text book, which was used by the subjects of this study.

STUDIES CONCERNING PRACTICE MATERIALS

There have been many studies which attempted to find out what happened when practice materials were altered.

Bell[53] attempted to learn what would occur if the percentage of frequently-used words was varied, while holding constant the syllabic intensity and the stroke intensity or word length. One version of the copy material had 100 per cent of the words drawn from a list of frequently-used words. Other versions contained 75 per cent, 50, 25, and 5 per cent of the words drawn from the same word list of frequently-used words.

As expected, significantly higher gross speeds were obtained

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[52] Ibid., pp. 4, 12.

[53] Mary L. Bell, "Some Factors of Difficulty in Typewriting Copy," (Unpublished Ed. D. Thesis, University of Oklahoma, 1950), pp. 14-17, 32-35.

as the copy increased in its content of frequently-used words. A second series of tests confirmed the findings, except that one of the four comparisons was reversed, with copy containing only 75 per cent of frequently-used words being typed faster than "easier" copy of 100 per cent frequently-used words. Thus seven of the eight comparisons were positive and significant, while one was negative, but non-significant.

The same study compared results obtained when the words in the copy increased in length, while holding constant the syllabic intensity, and the percentage of frequently-used words. Mean lengths of words in different versions of the test copy were spaced out from a low of 4.70 strokes to a word, to a high of 6.99 strokes to a word. The usual calculation of gross typing speeds was made, using 5.0 strokes to a word. Results showed that on two comparisons, from 4.70 to 5.11 strokes per word and from 5.11 to 5.53 strokes per word, the "shorter-words copy" was typed more slowly. The typing speed for the copy with 4.70 strokes per word was significantly slower than speed on the copy with 5.11 strokes per word. Above the 5.53 strokes-per-word level, however, the shorter-words copy was typed more quickly than the next level of longer-words copy on each comparison. Five of the six comparisons above the 5.53 strokes-per-word level showed the shorter-words copy as typed significantly faster than the longer-words copy. The other comparison was also faster for the shorter-words copy, but

not significantly so.[54]

These results would seem to indicate that up to a certain length, roughly 5.50 strokes per word, the shorter words are not the easiest to type. This would seem to contradict the frequently stated idea that word-response typing develops first on shorter words.

Green[55] discussed the swing in typewriting instruction books away from the use of nonsense word materials and toward the use of ordinary words, and particularly toward the use of the one thousand most common words as basic drill material. In an experiment his control classes used drill material taken from the one thousand most common words, and experimental classes used drill material stressing uncommon words. The drill materials were used for ten minutes each day, between the third and the fifteenth weeks of instruction. In the earliest testing of the groups, the students who had practiced on the most common words were clearly faster. By the end of the experiment, the experimental group had caught up or gone ahead in each of four pairs of classes. Only the slower students remained better after the common-word drills, at the end of the fifteen weeks.

Intermediate tests indicated when automatization seemed to appear, as judged by the increases in speed. The classes

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[54]Ibid., pp. 14-17, 54.

[55]H. H. Green, "Common Versus Uncommon Words as Drill Material in Typing," (Unpublished Master of Arts Thesis, University of Iowa, 1931), 72 pp.

drilled on common words seemed to show increases which could perhaps be attributable to automatization at, generally, about four or five weeks. Those without special drill on common words did not seem to achieve automatization of common words in most cases until after the tests at the end of eleven weeks and before the final test at the end of fifteen weeks. Green apparently assumed here that the gain in speed was due to the automatization of common words.

Rowe[56] attempted to learn which combinations of strokes would be most worthwhile for drill materials, based on the thousand most common words. He studied the two-letter, three-letter, four-letter, and five-letter combinations actually occurring in the one thousand words. The number of theoretically possible stroke combinations is over ten million, but he isolated some nine hundred combinations which appeared frequently enough to be considered important, and on which he would base drill materials for the early weeks of typewriting instruction. All of this directly assumed the value of stressing the common words, and trying to automatize them as soon as possible by frequency of repetition.

Miller, Bruner, and Postman[57] tested handwritten recall of nonsense letters exposed tachistoscopically for decreasing portions

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[56] C. E. Rowe, "Importance of Two, Three, Four and Five-Letter Combinations on the Basis of Frequency in a Word List," (Unpublished Master of Arts Thesis, University of Pittsburgh, 1930).

[57] G. A. Miller, J. S. Bruner, and L. Postman, "Familiarity of Letter Sequences and Tachistoscopic Identification," Journal of General Psychology, Vol. 50 (1954), pp. 129-39.

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of a second. Four different series of eight-letter nonsense words were used, the "most familiar" being made up of random selections of four letters which had appeared consecutively in ordinary language. The "least familiar" had eight letters chosen at random from the alphabet, regardless of frequency of use. The "most familiar" set of words could be picked out in smaller fractions of a second, and could be recalled more accurately than the others. There was a decrease in speed of seeing, and accuracy of recalling, through each gradation of familiarity. One of their conclusions was:

> It follows . . . that the more frequently a trace has been embedded in a trace aggregate, to use the language of Gesalt (sic) theory, the greater the probability that the aggregate will be aroused when a component is activated.[58]

It would seem that something of this nature is true in the building up of word response typing habits, through frequency of use of common words or common combinations of letters.

West[59] tried different types of practice materials for the first two hours of typewriting instruction. With one group he used nonsense word material of the type used in the early lessons in most typewriting text books, in which the strokes are repeated frequently and each finger moves around its home-key position. This material is easy to type, and the students using it typed

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[58]Ibid., p. 138.

[59]L. J. West, "An Experimental Comparison of Nonsense, Word, and Sentence Materials in Early Typing Training," Journal of Educational Psychology, Vol. 47 (1956), pp. 481-9.

many more strokes than did the students using other material. One other group typed alphabetic sentences, where every letter of the alphabet is included in each sentence. Another group used short words, three to five letters in length, but not arranged in sentences. A fourth group used longer words, varying from two to seven words, also not arranged in sentences.

After testing on sentence material, and also on five-letter code groupings, which are a form of nonsense letter material, he found that the long-word group was fastest in typing both types of test material, with the short-word group next, then the sentence material group, and the nonsense material group slowest. The first three groups were all significantly faster than the slowest nonsense-word group when typing the ordinary sentence-material test. With the code group test, each group finished in the same order, but only the long-word group was significantly faster than the nonsense-word group.

It is surprising that the nonsense-word drill materials were so ineffective, especially as West stated that the students typed many more strokes on this easy practice material than did the other groups.

West speculated that the nonsense-sequence practice might have held students on a stroke-by-stroke basis, while the word and sentence materials offered opportunities very early for better students to start crowding some of the more common letter sequences. The word and sentence materials would provide the opportunity for

better students to apply their individual readiness to advance toward higher-order habits. While not statistically significant, it is at least interesting that the long-word group led the short-word group in speed, whereas most authors have assumed that the short words were the ones on which to practice, and where higher-order habits would first show to real advantage.

Fuller[60] pointed out that the typewriting process places no strain on the slowest reader, as far as rate of reading is concerned. "The eye will grasp a combination of letters (not necessarily words, but sufficient letters) to feed copy to the hand as is needed according to the speed of typewriting."[61]

He concluded that copy should be presented in word wholes, but he believed using isolated words for practice material was as bad as using isolated strokes. He advised that typists should not attempt to read too far ahead in the copy: "A certain time interval is necessary to give a proper cue (probably one second); but beyond this time interval looking ahead in the copy is apt to cause errors."[62]

The time interval of one second which Fuller mentions appears to come from the work of Butsch,[63] who measured the eye-hand

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[60] D. C. Fuller, Reading Factors in Typewriting, (Stillwater, Oklahoma: Oklahoma A. & M. College, 1945), 112 pp.

[61] Ibid., p. 98. [62] Ibid., p. 99

[63] R. L. C. Butsch, "Eye Movements and the Eye-Hand Span in Typewriting," Journal of Educational Psychology, Vol. XXIII (February, 1932), p. 104-121.

span of typists of different abilities, and found that the hand trailed behind the eye fixations by averages between 3.24 and 7.60 letters. Generally, the eye-hand span became larger as the speed of typing increased. The greatest number of strokes Butsch observed in a single eye-hand span was 13, and often typists' eyes stayed on the letter until it was struck, an eye-hand span of zero letters.

Fuller's comment about needing a certain time interval to give a proper cue is supported in a study by Margaret Vince.[64] She pointed out that responses to discrete stimuli were limited to about two stimuli per second, unless the stimuli were presented in such a manner that several of them could be perceived as one unit. She referred to a "psychological refractory period" of about 0.5 seconds, during which a response to a second discrete stimulus would be delayed. Her subjects used a telegraph key to duplicate stimuli presented to them visually, and if the stimuli were suitably spaced and grouped the subjects could respond almost seven times a second, on a par with their maximum free tapping rate. However, when an overlapping of new stimuli occurred before response to earlier stimuli could take place, there was a breakdown of response, caused by "blocks" in the sensory-motor system.

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[64] Margaret A. Vince, "Rapid Response Sequences and the Psychological Refractory Period," British Journal of Psychology, Vol. 40 (1949-50), pp. 23-41.

Dvorak's[65] extensive coverage of the psychology and techniques of typewriting refers many times to the development of word response patterns. He states that typing habits are a form of shifting, conditioned behavior, and that typing offers a clearcut illustration of conditioning to countless slight signals or cues. Each better typing motion that appears does so as a new and complete pattern.[66] He states that "the isolated letter stroke is not even typewriting."[67]

Later he reviews the path the word-response pattern takes:

> As each finger motion creeps forward toward its conditioning signals, your rate of typing increases. As needless signals are dropped, you type familiar words with a correct ease. Early in your practice, for instance, the useless signals t, h, e disappear, and the merest outline of the sequence the is the new signal for your serial typing. Later in many familiar phrases the will drop out and the entire phrase will be typed at once from its mere phrase outline. This dropping out of letter cues and swifter emergence of complete words will be a common experience as your typing progresses.[68]

Dvorak believes firmly in typing words for practice material, and that these words should be in a sentence context.

SUMMARY CONCERNING REVIEW OF THE LITERATURE

Graphic recording of typewriting is not new, but was done very early in the century. In the earlier studies, it was usually coupled with introspective analysis. Graphic recording has shown

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[65] A. Dvorak, N. L. Merrick, W. L. Dealey, and G. C. Ford, Typewriting Behavior (New York: American Book Company, 1936), 521 pp.

[66] Ibid., p. x. [67] Ibid., p. xii. [68] Ibid., p. 117.

conclusively that expert typists vary the time taken for different combinations of strokes, with alternate-hand stroking being the fastest, appreciably faster than the maximum tapping rate for one finger. There are great variations within individuals in relative time taken to make different strokes, including space bar strokes, capital letter strokes, and carriage return movements, as well as the usual keyboard strokes. There appears to be a tendency for a typist to develop an individual pattern for typing certain words.

Introspective studies, especially those by Book and by Bryan and Harter, originated the idea of the existence of a higher-order level of typing, above the letter-by-letter stroking. These introspective studies indicated that there might be several levels of higher-order habits such as syllable, word, or phrase levels.

Some instructional materials ignore the question of stroke-response and word-response levels of typing. Others apparently make a deliberate effort to help the student reach a word-response level early, including grouping of more than one word for typing by word response. Some books intended for typewriting teachers support the whole concept of word response typing, and give suggestions to assist in attaining word response. One author, with supporting evidence, questions whether phrase-level typing exists at all, and even whether whole words are typed at a word-response level of skill.

There have been a number of studies concerning the practice materials to be used, and the majority agree that nonsense-word material should be eliminated or, at most, used for only a few moments after the introduction of a new key. Sentence material is favored over material made up of unconnected words. The thousand most common words were used as the basis for practice drills in many books, apparently on the assumption that word-response typing would build up more quickly with such materials. Some studies, however, have implied that any gains of this nature would be only for a short period, and that ultimate results would favor using ordinary unselected vocabulary for practice material from the earliest days. With this unselected material, the typist would encounter a broad range of typewriting situations, while still meeting the thousand most common words often enough to build up a word-level skill on them. There is conflicting evidence as to when automatization commences, or begins to show benefits. Two studies seemed to imply that automatization of skill did not necessarily appear first with the very short words, but that longer words also attained some form of early word-response gain.

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CHAPTER III

DESIGN AND PROCEDURES

PREPARATION AND DESCRIPTION OF COPY MATERIAL

For testing of the three hypotheses, the word "the" was selected, as this is the most common three-letter word in the English language. For verification, the word "and" was selected, as this is the second most common three-letter word. Special copy was constructed which grouped closely as many uses as possible of the three-letter combinations, "the" and "and."

The recording apparatus could record for only one hundred seconds at a time, but it was not found possible to put the necessary three-letter combinations into one one-hundred-second recording to give suitable tests of the hypotheses. Therefore the copy was split into two portions, each expected to be typed in less than ninety seconds. These were termed "Copy 1" and "Copy 2," in the order in which they were to be typed. Copy 1 is shown as Figure 1, and Copy 2 is shown as Figure 2.

Because of the possibility that the nonsense words might disrupt the accustomed typewriting patterns, the nonsense words were all grouped in the final part of the copy, approximately the last two-thirds of Copy 2. Copy 1 and the first portion of Copy 2 consisted of English-language words, and were considered as being one unit.

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Copy 1 consisted of eight lines and 377 strokes. The English-language portion of Copy 2, to the mid-point of Line 11, added 123 strokes, making a total of 500 strokes. Copy 2 consisted of seven lines and 357 strokes, including the nonsense-word portion of 234 strokes.

Line		Total Strokes	Measured Strokes
1	In theory the landowner handles his land with_	46	39
2	a landman for handy help._ Their other landlady_	48	39
3	is the antithesis of bland and blithe when she_	47	44
4	drinks authentic ale in the chandler shop. It_	47	38
5	seems neither the brother nor the glandular man_	48	39
6	can smother any demand there is to remand them for_	51	47
7	the theft of the theme too. We handle these and_	49	45
8	note they gather air at the toe and heel.	41	32
	- o - o -	377	323

Note: Syllabic Intensity 1.34

FIGURE 1

COPY 1, SHOWING IDENTIFYING LINE NUMBER AND NUMBER OF STROKES
(Unmeasured Strokes Are Underlined)

The words at the beginning of each line were not measured and tabulated, because of the interruption of stroke timing caused by the carriage return. To reduce the work required for tabulation

of measurements, words and strokes which would not affect the analyses were also omitted from the measurements. The omitted words and strokes are underlined on Figures 1 and 2.

Line		Total Strokes	Measured Strokes
9	Now they rue their handling of it and either she_	49	45
10	or her mother will then hand a tithe to their own_	50	43
11	church for aid and help. An ednand and other tathefs_	54	47
12	will understand when the fathers udatheac. Thus_	49	41
13	if neither ithet nor thej is handling the leathers,_	52	49
14	we heitheg them and undetsfand and then demand they_	52	49
15	be termed the jandkung or the fathead and meathead.	51	42
	- o - o -	357	316

Note: Syllabic Intensity 1.34

FIGURE 2

COPY 2, SHOWING IDENTIFYING LINE NUMBER AND NUMBER OF STROKES
(Unmeasured Strokes Are Underlined)

Of the total of 734 strokes, 639 were measured and tabulated. Of the measured and tabulated strokes, 429 were in the English-language portion, and 210 were in the nonsense-word portion.

Measurements by Coover[1] showed that sequence of two

[1]J. E. Coover, "A Method of Teaching Typewriting Based Upon a Psychological Analysis of Expert Typing." Proceedings (National Education Association, 1923), pp. 562-3.

opposite-hand strokes could be typed much more quickly than other sequences typed with fingers of the same hand. Both "the" and "and" have this opposite-hand stroking pattern. From a space bar stroke made with the right hand, a "t" is struck with the left hand, an "h" with the right hand, an "e" with the left hand, and finally a space bar stroke with the right hand. "And" follows the same pattern of alternating hands with each successive stroke. For comparable analyses, the opposite-hand pattern of strokes was maintained for words to be analyzed, especially for strokes immediately preceding and following the "the" and "and" sequences of strokes. There were some situations where suitable opposite-hand words could not be found, such as eight-letter words containing any "the" combination. In some other cases, also, words with less ideal stroking patterns had to be used, such as following the left-hand "e" with another left-hand stroke in such words as "other," "either," etcetera.

In trying to use alternate-hand words containing "the" and "and" three-letter combinations, some unusual words were included, making it difficult to put the desired words into sentences with a flow of meaningful content. In the English-language portion of the copy the sentences were not designed to lead logically from one to the next. Because of this, the subjects were warned not to worry about the meaning of what they were typing. In the nonsense-word portion of the copy, the periodic interjection of a nonsense word completely destroyed all meaning and, again, the

subjects were warned not to be concerned about the lack of meaning in the words and sentences. Each nonsense word did, however, appear in a sequence of English-language words, just as if it were a regular word in a proper sentence.

In constructing nonsense words to compare with English-language words, it was possible to keep the stroking patterns comparable. For example, "tathefs" was devised to be compared with "fathers." These two words not only follow the same pattern of right-or-left-hand stroking, but actually require the use of the same fingers in the exact sequence. Some words were harder to match or make comparable. For example, "ithet" was devised for comparison with "other." "Other" is a short word and it was desired to leave the "the" combination in the middle untouched, which left only two letters which could be changed. Therefore, "i" was substituted for the initial "o," and the final "r" was changed to a same-finger stroke, "t," to produce the nonsense word, "ithet," which had a similar stroking pattern, and could probably be typed with equal physical ease.

Early drafts of the proposed copy material were tried out on experienced typists. Their hesitations at some parts of the copy, especially on some nonsense words, led to revisions. The final copy material could be typed by experienced typists without any major hesitations.

The words to be compared in the testing of Hypothesis I

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are shown in Table I. Hypothesis I states: "There is no significant difference between the time required for the typing of frequently-typed three-letter combinations when they appear in actual frequently-typed words, and when they appear in non-English-language words of similar stroking patterns."

All of the words for comparison are in the nonsense-word section, the last two thirds of Copy 2. The frequency of use of the actual words is shown, as determined by Silverthorn.[2] In 300,000 words of business vocabulary material, Silverthorn found that 11,564 different words were used. He tabulated the number of times each was used, and listed the 4,950 most common words in order of their frequency of use. All of these listed words occurred four or more times. The frequency of occurrence of nonsense words and certain other words in Copy 1 and Copy 2 is shown as zero because they were not encountered by Silverthorn in his 300,000-word sample.

The words to be compared in testing Hypothesis II are shown in Table II. Hypothesis II states: "There is no significant difference between the time required for the typing of frequently-typed three-letter combinations and of three-letter combinations of similar stroking patterns which are less frequently typed.

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[2] J. E. Silverthorn, Word Division Manual (Cincinnati: South-Western Publishing Company, 1958), 109 pp.

TABLE I

ENGLISH LANGUAGE AND NONSENSE WORDS

TO BE COMPARED IN TESTING HYPOTHESIS I

Word	Location in Copy (Line)	No. of Occurrences in Silverthorn List
4-letter words		
thej	13	0
they	14	626
them	14	460
then	14	178
5-letter words		
ithet	13	0
other	11	498
6-letter words		
ednand	11	0
demand	14	64
7-letter words		
heitheg	14	0
neither	13	12
tathefs	11	0
fathead	15	0
fathers	12	5
8-letter words		
jandkung	15	0
handling	13	50
9-letter words		
udatheac.	12	0
meathead.	15	0
leathers,	13	*
10-letter words		
undetsfand	14	0
understand	12	55

* No. of occurrences is only 1, 2 or 3

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

TABLE II

THREE-LETTER COMBINATIONS AS COMPLETE WORDS

TO BE COMPARED IN TESTING HYPOTHESIS II

Word	No. of Occurrences in Copy	Location in Copy (Lines)	No. of Occurrences in Silverthorn List
rue	1	9	0
toe	1	8	*
she	2	3,9	59
for	3	2,6,11	4,498
the	7	1,3,4,5(1),5(2),7,8	16,234
ale	1	4	0
aid	1	11	31
air	1	8	73
and	5	3,7,8,9,11	7,730

* Number of occurrences is only 1, 2, or 3

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

In these comparisons, frequency of typing the word is the critical factor. All the words used for comparison have alternate-hand stroking. "Rue" uses the exact fingers, in the same sequence, as does "the." "Toe" and "she" have two of the three strokes identical with "the." Similarly, "ale" and "aid" have two of the three strokes matched with the fingers and sequence used in "and."

Since all of these three-letter words use the same alternate-hand stroking patterns, it could be expected that the physical movements of typing them could be made with similar speed, unless the frequency of typing some of the combinations had developed a skill in grouping the three strokes together in a faster sequence. Therefore, the frequency of occurrence in business vocabulary was considered important.

The word "the" is the most common word in the English language and Silverthorn found it used 16,234 times in the 300,000 words he analyzed. The word "and" is the fourth most common word, with a frequency of use of 7,730 times. It is the second most frequent three-letter word.

Table III shows the "the" words used in comparing for the testing of Hypothesis III. Hypothesis III states: "There is no significant difference between the time required to type common three-letter combinations occurring as separate words, and the time required to type the same combinations occurring in longer words."

Here, the three-letter combination, "the," appears as a complete word and the same three-letter combination appears as

TABLE III

"THE" COMBINATION AS A SEPARATE WORD

TO BE COMPARED WITH

"THE" COMBINATION AS PART OF LONGER WORDS

Word	No. of Occurrences in Copy	Location in Copy (Lines)	No. of Occurrences in Silverthorn List
Separate Word			
the	7	1,3,4,5(1), and 5(2),7,8	16,234
4-Letter Words			
they	2	8,9	626
them	1	6	460
then	1	10	178
5-Letter Words			
their	2	9,10	508
other +	1	2	498
theme	1	7	5
tithe	1	10	*
6-Letter Words			
either +	1	9	89
theory	1	1	9
mother +	1	10	5
blithe	1	3	0
7-Letter Words			
neither +	1	5	12
brother +	1	5	11
smother +	1	6	0
9-Letter Words			
authentic	1	4	*
10-Letter Words			
antithesis +	1	3	0

+ These words do not have opposite-hand strokes following the "the" combination

* Number of Occurrences is only 1, 2, or 3 times

part of longer words. The comparisons could indicate whether skill in typing a three-letter combination transfers to the typing of the same combination in short words, and also in longer words.

Table IV shows the "and" three-letter combinations used for further testing of Hypothesis III.

With longer words it becomes more difficult to maintain the desired alternate-hand stroking throughout the entire word. However, the strokes immediately preceding and following "the" and "and" do maintain the alternate-hand pattern, except for seven words as noted on Table III.

SELECTION OF SUBJECTS

Subjects were wanted from those who might be expected to have been typing long enough to develop word-response typing habits, at least on some combinations of strokes. For this reason, students in Alberta's Typewriting 20 course were used. For most students this is their second year of typewriting instruction.

To obtain "average" or "typical" students, those students with the lowest and highest speeds in each class were eliminated. In Alberta the minimum speed standard for second-year typewriting students to obtain a mark of 50 per cent is 40 gross words per minute for five minutes of typing.[3] The students having the highest

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[3]Alberta Senior High School Curriculum Guide for Business Education (Edmonton, Alberta: Department of Education, Province of Alberta, Canada, September, 1960), p. 31.

TABLE IV

"AND" COMBINATION AS A SEPARATE WORD

TO BE COMPARED WITH

"AND" COMBINATION AS PART OF LONGER WORDS

Word	No. of Occurrences in Copy	Location in Copy (Lines)	No. of Occurrences in Silverthorn List
Separate Word			
and	5	3,7,8,9,11	7,730
4-Letter Words			
hand	1	10	90
land	1	1	19
5-Letter Words			
handy	1	2	11
bland	1	3	0
6-Letter Words			
demand	1	6	64
handle	1	7	51
remand	1	6	0
7-Letter Words			
handles	1	1	4
landman	1	2	0
8-Letter Words			
handling	1	9	50
chandler	1	4	0
landlady	1	2	0
9-Letter Words			
glandular	1	5	*
landowner	1	1	0

* Number of occurrences is only 1, 2, or 3 times

[illegible]

speeds usually type approximately 65 gross words per minute toward the end of the school year. The subjects in this study were to be tested in the month of May, 1964, toward the end of their school year.

From each class included in the study the teacher was asked to send in for measurement those students who in five-minute writings were typing at a gross speed of 50 w.p.m., plus or minus three w.p.m. There is always a certain amount of fluctuation in any individual's speeds on different timed writings, and in some classes the teachers had been emphasizing other production-typing tasks and had not recorded a timed-writing speed for some weeks. As a result, more variation in speeds was obtained than had been requested, but the intention of eliminating the slowest and fastest typists was still achieved.

The forty students whose graphic records were used were selected from eight Typewriting 20 classes, five from each class. These classes were in three different high schools, one in Edmonton, Alberta, and two in Calgary, Alberta. Each of the classes had a different instructor.

All students sent for measurement by their teachers had graphic recordings made while they typed Copy 1 and Copy 2. In seven of the eight classes, more than five students were graphically recorded in this way, and the five sets of measurements to be used had to be selected from the seven to ten sets of measurements which were available for the class.

The primary basis of selection was to eliminate those students who had required, for typing Copy 1 and Copy 2, appreciably more or appreciably less time than the median time for all students. A few students who would have been included on this speed basis were then eliminated on the basis of an extreme number of errors, since the amount of usable data remaining would have been unsatisfactory after all the affected strokes had been removed. Those students eliminated were replaced by others with fewer errors, but whose typing times were still close to the median for the entire group.

A summary of the times required for typing Copy 1 and Copy 2 is given in Table V. The number of errors on each set of copy is also shown. Under the heading of Student Identification Number" the first numeral, before the decimal point, is the class number. The second numeral, after the decimal point, is an identifying number for the student within the class.

Examination of Table V shows that the mean time for typing Copy 1 was 80.67 seconds, which on 377 strokes of copy gives a gross speed of 56.08 words per minute. The mean time for typing Copy 2 was 81.0 seconds, which for 357 strokes gives a gross speed of 52.89 w.p.m. It should be noted that Copy 2 included all of the nonsense words. Mean of the total time for typing both Copy 1 and Copy 2 was 161.9 seconds, which for 734 strokes gives a mean gross speed of 54.40 w.p.m.

TABLE V

TYPING TIME AND ERRORS ON COPY 1 AND COPY 2

BY INDIVIDUAL STUDENTS

Student Identification Number	Time, in seconds			Errors		
	Copy 1	Copy 2	Total	Copy 1	Copy 2	Total
1.1	81	81	162	10	8	18
1.2	87	87	174	4	7	11
1.3	84	86	170	2	3	5
1.4	77	76	153	3	8	11
1.5	88	-	176+	4	2	6
2.1	89	83	172	12	9	21
2.2	87	87	174	2	3	5
2.3	76	78	154	6	6	12
2.4	78	86	164	0	3	3
2.5	84	-	168+	6	8	14
3.1	82	83	165	3	6	9
3.2	78	77	155	8	10	18
3.3	81	82	163	10	6	16
3.4	78	80	158	4	3	7
3.5	84	87	171	1	5	6
4.1	80	78	158	4	7	11
4.2	83	79	162	6	3	9
4.3	78	76	154	5	4	9
4.4	83	81	164	7	1	8
4.5	80	78	158	6	6	12
5.1	80	83	163	8	9	17
5.2	71	78	149	4	4	8
5.3	82	79	161	6	8	14
5.4	81	84	165	3	2	5
5.5	74	73	147	3	4	7
6.1	83	84	167	8	8	16
6.2	75	76	151	3	4	7
6.3	74	76	150	6	7	13
6.4	-	81	162+	8	4	12
6.5	79	-	158+	5	8	13

Continued

TABLE V (continued)

Student Identification Number	Time, in seconds			Errors		
	Copy 1	Copy 2	Total	Copy 1	Copy 2	Total
7.1	79	78	157	4	4	8
7.2	79	89	168	1	2	3
7.3	82	81	163	4	2	6
7.4	80	83	163	4	3	7
7.5	78	78	156	6	6	12
8.1	77	77	154	5	8	13
8.2	86	86	172	7	6	13
8.3	86	84	170	7	6	13
8.4	84	-	168+	3	3	6
8.5	78	80	158	7	9	16
High	89	89	176	12	10	21
Low	71	73	147	0	1	3
Mean	80.67	81.00	161.90	5.08	5.55	10.50
Stan. Dev.	3.99	3.95	3.75	2.44	2.90	4.77

+Note: Where no time is shown for typing of Copy 1 or Copy 2, the examiner failed to obtain the time accurately. In such cases, the "Total" time is treated as being twice the time for whichever Copy was measured successfully.

It should be noted, however, that even though the extremes of high and low speeds had already been eliminated a wide range of speeds remained. Table V shows that on Copy 1 the fastest subject took 71 seconds, and the slowest took 89 seconds, a range from 63.72 w.p.m. to 50.83 w.p.m. On Copy 2 the range was from 73 to 89 seconds, or from 58.68 to 48.13 w.p.m. Over-all time, on both Copy 1 and Copy 2, ranged from 147 to 176 seconds for the 734 strokes, or from 59.92 to 50.05 w.p.m.

Of the thirty-five subjects for whom times for typing both Copy 1 and Copy 2 were available, thirty typed Copy 2 within plus or minus three seconds of the time taken for typing Copy 1. The other variations were 4, 6, 7, 8, and 10 seconds. It is noteworthy that the two students with the widest variations, of eight and ten seconds, both typed Copy 2 more slowly than Copy 1. Also, these two students had the least number of errors of the entire group, each with only three errors for Copy 1 and Copy 2 combined.

The mean number of errors was 5.08 on Copy 1, and 5.55 on the slightly shorter Copy 2, with a mean of 10.50 errors on the combined material. Two students had only 3 errors on Copy 1 and Copy 2 combined. Next lowest were three students with 5 errors. The greatest number of errors was 21, and two subjects had 18 errors.

The number of errors was higher than is usually expected in the limited number of strokes being copied. Several factors could have contributed to this lack of accuracy. One obvious factor was

the presence of nonsense words in Copy 2. Despite telling students to pay no attention to the meaning, it is probable that the lack of continuity of meaning troubled some of them. The use of an unfamiliar typewriter, although the subjects were given practice time for familiarization, undoubtedly contributed to some of the errors. However, this did not seem to be as large a factor as the author had expected. Nervousness may have been a factor but this was apparent in only a few of the subjects.

DESCRIPTION OF RECORDING APPARATUS

Apparatus for recording the moment of making ordinary key strokes and space bar strokes was attached to a manually-operated Underwood typewriter. This typewriter, Serial 11-6926766, was approximately thirteen years old, but was in excellent condition, having been cleaned and adjusted by the manufacturer's local agency just before being set up for the testing. The age of the machine made it unlikely that any of the students would have practiced on this type of machine in school, and therefore all students would be at an equal disadvantage in typing on a machine with an unfamiliar "feel."

A micro-switch was attached to the back of the typewriter in a position where every key stroke would depress the switch and complete an electrical connection. Another micro-switch was bolted to a board beneath the arm of the space bar lever in such a position that pressing the space bar would depress the switch and complete another electrical connection.

The two switches were connected by wiring, about three and a half feet long, to a recording oscillograph, on which a pen traced an ink line on a strip of chart paper driven under the pen at a constant rate. Ordinarily this pen moved along a "base line," but when a key-stroke depressed the first micro-switch, the pen immediately jerked about one half-inch to the side, and traced a line in this different position until the key was released, when the pen resumed the "base line" position. Similarly, a space bar stroke completed a connection through the second micro-switch, and this jerked the pen a half-inch to the other side of the base line, where it remained until release of the space bar allowed it to spring back to the "base line."

The visible ink line gave a permanent record for quantitative measurement of the distance on the paper between each stroke, and since the paper was driven at a fixed speed, this gave an objective measure of the time between strokes.

The fact that space bar strokes appeared in a different position from the ordinary key strokes assured a clear record of the changes from one word to the next.

Photographs of the recording apparatus connected to the typewriter, and of the wiring diagram for the electrical hookup, are included as Appendix A and Appendix B respectively. It should be noted that the wiring diagram includes a third micro-switch attached to the shift key of the typewriter, for study of capital-letter stroking. This capital-letter feature was not, however,

used in this study.

The recording oscillograph device, an "Electrodynamic Recorder" Model GA-1023, was manufactured by Massa Laboratories Inc., of Hingham, Massachusetts. Because this recorder operated on DC current, an inexpensive battery charger was attached to convert household 110-volt AC current to the required 12-volt DC current. The battery charger used was a "Carter Battery Charger," Model 1220, manufactured by James B. Carter Ltd. of Winnipeg, Manitoba.

The chart paper used for recording was No. C3161, distributed by Electrodynamic Instrument Corporation of Houston, Texas. This was a smooth-surface paper with a slightly waxy finish, non-stretching qualities, and with a fine graph ruling. The strip was two and one-half inches wide.

A photograph of a recorded strip of the chart paper, showing the ink-line movements, is included as Appendix C. Certain key strokes are indicated, and the tracing shows the pen jerked from the base line, returning to the base line as each key is released, and jerking from the base line with the next stroke. A space bar movement is also shown.

ADMINISTRATION OF TIMED WRITINGS TO SUBJECTS

One person administered the typing and recording of Copy 1 and Copy 2 to all the subjects, thereby assuring a high degree of consistency of administration.

A "trial run" was made with several typists before procedures for administering the timings were fixed. It was immediately obvious that nervousness was a prominent factor with some of the typists, who spoke of being troubled by the examiner's presence, the awareness of the recording machine, the difference in typewriter "feel," etcetera. With the thought that fast typing might best illustrate the presence or absence of word-response typing, a few of these trial typists were instructed to type at their highest speed. This pressure seemed to upset them, so that they made numerous long pauses, typed jerkily, and made numerous errors, all of which were quite untypical of their usual typing performance.

As a result of these observations, it was decided that emphasis in administering the timed writings of the material must be on (1) putting the subject at ease to lessen the nervousness, and (2) not putting the subject under pressure to type at high speed. It was felt that complete consistency of administration, which could only be obtained by reading the instructions to the subjects, should be de-emphasized in favor of trying to reduce the nervousness factor by building friendly and personal relationship between the test administrator and the subjects. Accordingly a written list of directions was not used, but the test administrator memorized a check list of directions, and rehearsed the key phrases to standardize the most vital instructions.

A number of the subjects expressed nervousness when they first came into the recording room, but only two or three showed visible nervousness after a few minutes. These subjects made so many errors that their work was not used in the study. The test administrator felt that, while nervousness was undoubtedly present with some of the subjects, it would not appreciably affect the typing patterns of those students included in the study.

The procedure in test administration followed these steps:

1. The subject was informed that this was not a test of his typing. The object of the study was explained.
2. The recording apparatus was demonstrated briefly.
3. The student practiced on the test typewriter, until the test administrator thought he was typing steadily and fairly accurately.
4. He was given a one-minute timed writing to check that his speed was in the desired range, and that he was not making too many errors. If errors were extreme, he did more familiarization practice and then took another one-minute writing.
5. The recording apparatus was connected to the typewriter, and the subject was shown Copy 1. He was told to return the carriage at the ends of lines as shown in the copy; to pay no attention to the meaning; and to type for control rather than for speed.

6. The subject typed Copy 1, with the recording apparatus operating. With a stop watch, the administrator timed the period for typing the entire copy.
7. A new roll of paper was put on the recording apparatus, and the subject was shown Copy 2, with repetition of the advice concerning margins, lack of meaning in the copy, and typing for control rather than for speed.
8. The subject typed Copy 2, with the recording apparatus operating. Timing was again obtained with the stop watch.

On a few occasions, the subject's typing had to be halted because the ink flow to the recording pen was not free enough to give a satisfactory tracing for measurement. After the fault was corrected, the student began to type seven or eight words before the interruption point, so there would be an overlapping section of the recorded copy. In measuring and tabulating the time for strokes, the first typing was used as far as the recording ink was clear enough for accurate measurement. Then the measurement would be moved forward to the next letter on the second typing of the same words.

These interruptions because of apparatus problems caused five instances where an accurate timing was not obtained for the typing of that copy. In all such cases, however, an accurate time

was available for the student's typing of the other set of copy. Therefore, typing time for the untimed run was considered as being the same as had been obtained for the typing during the successfully-timed run.

MEAUREMENT AND RECORDING OF DATA

As the paper on the recording oscillograph was driven at a constant speed, distance on the paper was equivalent to a certain passage of time. The distance between two strokes visibly jerking the pen off the "base line" represented the time interval between the strokes, and it was considered in this study as being the time necessary to make the second of the two strokes. It was necessary to make as accurate a measurement as possible of the distance betwen the two departures from the base line.

For this measurement, a large measuring scale was carefully constructed, and then reduced photographically until its smallest units were just visible as distinct lines. This reduced measuring scale was printed on transparent film, so it could be placed directly over the traced line, and the separation lines on the scale could be readily seen, immediately adjacent to the desired points for measurement. A photograph of the measuring scale in shown in Appendix C.

Four different people made measurements on the recorded strips, and it was found that they could check one another's measurements and agree consistently within plus or minus one unit.

Each unit on the measuring scale was equivalent to approximately 1/920th of a second. To determine this, oscillograph tracings were made, using the recording apparatus, of the vibrations of an oscillator which, in different series of checks, was set to oscillate at 20, 40, and 50 cycles per second. The measuring scale was then used to measure the distance the paper moved during the 20, 40, or 50 graphically recorded cycles, or one second of time. The distance moved in one second was measured with the measuring scale, and the mean distance was about 920 units. Therefore each unit of measuring scale measurement is considered approximately equivalent to 1/920th of a second.

The first step in measuring and tabulating time intervals for strokes was to spread out a portion of the recorded strip of paper, and to mark on it the actual letters represented by the movements of the pen from the base line. This could be positively checked by examining the strokes visibly imprinted on paper by the keys and the typewriter ribbon during the recording. The number of strokes per word, between the opposite-side jerks on the tracing when space bar strokes were made, could be easily seen and followed. Any errors in the typing were visible on the typed sheet and were noted as incorrect on the recorded strip of chart paper. The letter typed by the key stroke was written on the record in ink, directly below the point where the pen jerked off the "base line."

The second step was to measure the distance between strokes. The measuring scale was positioned with its measurement line immediately beside the "base line" on the recorded strip, and the number of units, from one movement away from the "base line" to the next, could be easily read. The number of units was written in ink directly on the recording strip, between the two letters previously written on the strip.

The third step was to transfer these measurement figures to a master tabulating sheet. Each such sheet covered up to 21 strokes, and measurements for each stroke had to be accounted for, either by a correct measurement figure, or by a measurement figure which was circled to indicate that it represented an incorrect key stroke.

A check for accuracy of recording and measuring was made at this point. A gross measurement was made over the whole range of strokes listed on one master tabulating sheet, and the sum of all the individual measurements had to agree with the gross measurement, within a small tolerance of plus or minus three units.

Some adjustments to the data were made at this stage, to cover situations where incorrect keys had been hit, etcetera. The reasons and procedure for these adjustments are discussed under the heading, "Adjustments to Data." These adjustments were shown on the master tabulating sheets, while still preserving the original data.

I.B.M. cards were then punched and verified from the master

tabulating sheets for each subject. As there were 639 recorded strokes for 40 subjects, this gave over 25,000 measurements with which to work. The I.B.M. data cards, after further sorting and grouping, were then used for analysis of the data.

ADJUSTMENTS TO DATA

When a subject made an error in typing, such as typing "tje" instead of "the," the time for the incorrect "j" stroke could not be counted as the time for an "h" stroke. In the case of omitted strokes, or of extra strokes being inserted, it was impossible to record the times accurately for the key which should have been struck. Thus, errors left gaps in the data.

Many such errors affected two or more strokes. For example, after striking "tj," the typist might realize an error had been made and look up at the typed letters before proceeding with the "e" stroke. On the typed sheet the "e" would appear as correctly typed, but the time required for it might be completely untypical of that typist's usual time for the stroke.

In the case of an omitted letter, two strokes were always affected. If "an" were typed instead of "and," the "d" stroke left a gap in the data, but also a gap had to be left for the following space bar stroke, since striking the space bar after an "n" stroke is different from striking the space bar after a "d" stroke.

In a few cases failure of the recording apparatus left gaps in the data. This occurred when ink flow to the oscillograph

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pen thinned out so that the exact time of the stroke could not be read. Also, in a few cases a second stroke followed its preceding stroke so closely that the oscillograph pen did not have time to return to the "base line" before the second stroke. In such cases, the time for the second stroke could not be determined.

These situations all left gaps in the data. Because the method of statistical analysis to be used made it inadvisable to leave such gaps, an "average" figure was inserted on the master tabulating sheet in the place of any such gap. The "average" figure used for a stroke was the mean time taken by those typists who typed the stroke correctly.

A less obvious need for adjustment also arose in some instances where a typist typed the correct series of strokes, but took an exceptionally long time for one or more of them. Considerable variation in times taken by various typists for any one stroke was to be expected, but extreme variations could distort the data seriously, and destroy the purpose of analyzing the typical or usual typewriting behavior of these typists. For example, if thirty-nine typists required 100 units of time each to type a space bar stroke, but the 40th typist lost his place in the copy and took 7 seconds for that one stroke, the mean time for all 40 typists would rise from 100 to 237.5 units. To avoid serious distortions of this nature, the same "average" figure as described above was inserted to replace any untypically high figure. Any

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figure more than twice the size of the "average" figure was considered to be untypically high and was adjusted to the "average." This dividing point left ample room for individual variations, but screened out those times which were so high as to produce serious distortions.

The number of adjustments required, arising from both the visible errors and the untypically-high times required for strokes, varied considerably for different strokes. No adjustments were needed for 114 strokes. The mean number of adjustments for all the 639 recorded strokes was 2.48, with 12 adjustments being the greatest for any one stroke.

In Appendix D, the mean, variance, and standard deviation of times taken for each recorded stroke are shown. Also shown, under the heading, "No. of Adjustments," are the number of adjustments to the "average" figure for each recorded stroke.

PROCEDURES FOR ANALYSIS OF DATA

As one purpose of this study was to analyze three-letter combinations of "the," times for striking "t," "h," and "e" were combined. For each three-letter group thus obtained, the mean, variance and standard deviation of the times obtained by the 40 subjects were calculated. The "the" combinations were then arranged in ascending order of their means to indicate the relative speeds of typing different groups, and also to demonstrate the size of the differences in speed between the different groups. The "and" combinations were treated similarly.

Matched pairs of these three-letter combinations were then statistically analyzed for significant differences of performance. The method of statistical analysis used is one described by Winer[7] under the heading of "Single Factor Experiments Having Repeated Measures on the Same Elements." In this research, the 40 typists repeatedly typed the words "the" and "and" as separate words, but with different words and strokes preceding and following them. They also typed the same sequences of strokes where these appeared not as separate words but as parts of longer words or of nonsense words. The time for typing each of these three-letter sequences was measured, giving a series of repeated measures on the same elements, but with these elements appearing in somewhat different context.

In addition to differences in performance arising from the changes in context, or "treatment" as Winer terms it, there exist differences in performance inherent within the individuals, arising from their differences in typing ability existing at the time of typing the copy material. Winer's method attempts to separate the pre-existing variations between individuals from the "treatment effects." The method also attempts to separate the "experimental error," which consists of those variations within each individual's performance which cannot be accounted for by the change in "treatment" or context, from the remaining error which arises from the change in "treatment" or context.

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[7]B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book Co. Inc., 1962), pp. 105-139.

The statistical measure obtained by Winer's method, for the remaining effects arising from the difference in "treatment," is expressed as an "F-score," which can be used for a test of significance.

To obtain the F-score, Winer's formula[8] is:

$$F = \frac{\text{MEAN SQUARES}_{\text{treatment}}}{\text{MEAN SQUARES}_{\text{residual}}}, \text{ abbreviated as } \frac{MS_{treat}}{MS_{res}}$$

$$\text{where } MS_{treat} = \frac{\text{SUM OF SQUARES}_{treat}}{\text{DEGREES OF FREEDOM}_{treat}} = \frac{\dfrac{n(\bar{T}_1 - \bar{T}_2)^2}{k(k-1)}}{k-1}$$

$$\text{and } MS_{res} = \frac{\text{SUM OF SQUARES}_{res}}{\text{DEGREES OF FREEDOM}_{res}}$$

$$= \frac{\sum\sum\left[(X_{ij} - \bar{G}) - (\bar{P}_i - \bar{G}) - (\bar{T}_j - \bar{G})\right]^2}{(n-1)(k-1)}$$

when n = No. of subjects

k = No. of treatments (or contexts) being compared

X_{ij} = Each score obtained, or the score for each combination of subject and treatment

$\bar{G}$ = Mean of all scores, or the "grand mean"

$\bar{T}_1$ = Mean of scores by all subjects, for first treatment

$\bar{T}_2$ = Mean of scores by all subjects, for second treatment

$\bar{T}_j$ = Mean of scores by all subjects, for treatment "j"

$\bar{P}_i$ = Mean of scores for the different treatments, for subject "i"

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[8]*Ibid.*, pp. 109-110.

In this study, one treatment or context is compared with one other treatment at a time, for the 40 subjects. Thus $k = 2$ and $n = 40$.

For compilation of figures, Winer provides computation procedures which are easier to use than the above formulae.[9]

A basic assumption in Winer's method is that the population has an underlying multivariate normal distribution.[10] The nature of these scores for typewritten strokes, however, ensures that the distributions will not be "normal," but will be positively skewed. However, when the usual homogeneity assumptions are not met, a conservative test is suggested by Winer,[11] in which the F value determined from the tables tends to be somewhat larger than the exact value. This has the effect of requiring higher values for the F-scores arising from the effects of "treatment," or context, before these values are considered significant. The values obtained by this conservative test are used in this study as determining whether results are significant or not. An F-score value of 4.09 or higher would indicate a significant difference at the .05 level which is to be used in this study. If a test of significance at the .01 level were desired, the F-score must be 7.33 or higher.[12]

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[9] Ibid., p. 110.

[10] Ibid., p. 106.

[11] Ibid., p. 123

[12] Ibid., p. 646.

CHAPTER IV

ANALYSIS OF RESULTS

Data used in analysis of results are shown in Appendices D, E, F and G.

Appendix D provides information concerning each of the 639 measured and tabulated strokes. The key stroke shows in the left column, with each space bar stroke being indicated by an asterisk. The 40-subject total time, mean time, variance, standard deviation, and the number of adjustments to the mean time are all indicated. The headings indicate the master tabulating sheet on which the strokes were recorded, and the line of copy from which they were typed.

Appendix E shows a grouping of times for the three strokes in each three-letter combination used in the analysis procedures. For example, in Line 2 the word "other" contains the three-letter combination "the." Times for the "t," "h," and "e" have been added together for each subject, and are shown in Appendix E in Column 1 of the list for Card 51. The card number is the number of the I.B.M. card on which this data was stored. Cards 51 to 57 record information on strokes made from the Ordinary Word portion of the copy, and Cards 61 to 63 record data on strokes from the Nonsense Word portion. Each subject's identification number is shown in the left column, under the heading "SUB."

Appendix F reports for each of these three-letter groups of strokes the total times for all 40 subjects, the mean time, the variance, and the standard deviation. Again, this information is listed according to the I.B.M. card on which the information is contained.

Appendix G gives information about the individual performance of each subject in his typing of the copy. Reported for each individual are the total times for all his strokes in that portion of the copy, the mean, variance, and standard deviation. This Appendix is broken into three parts, one for the Ordinary Word portion of the copy, one for the Nonsense Word portion of the copy, and one for over-all performance on the Entire Copy.

In testing the hypotheses, the times obtained by each subject for the three-letter groups of strokes were used, as listed in Appendix E. Times by all subjects for one three-letter group of strokes were compared with the corresponding times for a second three-letter group of strokes, and statistical tests for significance were applied. In these comparisons the amount of difference was indicated by the F-score, or F-value, obtained. These values were compared to a Table of F Distribution shown by Winer,[1] to see whether a significant difference at the .05 level existed. If the difference exceeded the .01 level, this

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[1] B. J. Winer, Statistical Principles in Experimental Design (New York: McGraw-Hill Book Company, Inc., 1962), pp. 642-647.

was also noted. The critical values, above which the F-score would indicate a significant difference, were determined as 4.09 at the .05 level, and 7.33 at the .01 level.

TESTING OF HYPOTHESIS I

Hypothesis I states that there is no significant difference between the time required for the typing of frequently-typed three-letter combinations when they appear in actual frequently-typed words, and when they appear in non-English-language words of similar stroking patterns.

All words used in testing for this Hypothesis are taken from the Nonsense Word portion of the copy, which is the final section of Copy 2, from the beginning of a new sentence in Line 11.

<u>Comparisons Using "the" Combinations</u>. Table VI shows all the three-letter "the" combinations used in the Nonsense Word portion of the copy, arranged in rank order of the mean of times obtained by the 40 subjects.

In three of the four cases where "the" appears as a whole word the mean times, 451, 454, and 455 units, are very close. The fourth "the," however, has a mean time of 476 units, which was significantly different at the .01 level. The fourth "the" took significantly more time than did any of the other three.

The mean time for these four uses of "the" as a whole word was calculated as 460 units, and was statistically compared

TABLE VI

NONSENSE SECTION - "the" COMBINATIONS

USED IN TESTING HYPOTHESIS I

Word in Which Combination Used	Mean Time for 40 Subjects (Units)	Rank Order	Location (Line)
the	451	1	15-1
the	454	2	15-2
the	455	3	12
they	458	4	14
then	465	5	14
other	469	6	11
them	470	7	14
the	476	8	13
neither	476	9	13
leathers,	532	10	13
fathers	536	11	12
thej	558	12	13
fathead	586	13	15
meathead.	613	14	15
udatheac.	621	15	12
ithet	652	16	13
tathefs	690	17	11
heitheg	751	18	14
mean of "the"	460	-	4 cases

to the time for the typing of each "the" combination when it occurred as part of longer words. Results are shown in Table VII. "The" as a whole word was typed significantly faster, at the .01 level, than all four nonsense words; than the two "slang" words, "fathead" and "meathead."; and also than ordinary words, "fathers" and "leathers,". Differences were not significant for the remaining words.

Finally, matched pairs of ordinary and nonsense words were statistically compared. Each pair of words has a "the" combination at the same point within the words, and each pair has similar patterns of right-and-left-hand stroking. Six of the eleven pairs have stroking by identical fingers throughout the word.

Table VIII shows the F-values obtained for each comparison. Ten of the eleven were significantly different at the .01 level, with the ordinary word typed faster than the nonsense word. The only case where the difference was not significant was the comparison of "meathead." to "udatheac."

Comparisons Using "and" Combinations. For verification of results, the same calculations were made with "and" combinations as had been made with "the" combinations.

Table IX shows the rank order for all the different "and" combinations. The four occurrences of "and" as a whole word are grouped near the lower end of the times. On comparing each "and" with the others no significant differences were found.

TABLE VII

MEAN OF TIMES FOR "the" AS A WHOLE WORD

COMPARED TO OTHER "the" COMBINATIONS

IN NONSENSE WORD SECTION

Word	Frequency	Mean Time (Units)	F-Score
the	16,234	460	-
they	626	458	0.04
them	460	470	1.97
then	178	465	0.60
thej	0	558	56.18**
other	498	469	1.21
ithet	0	652	81.87**
neither	12	476	3.76
fathers	5	536	48.97**
fathead	0	586	78.88**
tathefs	0	690	97.26**
heitheg	0	751	123.85**
leathers,	1-3	532	39.83**
meathead.	0	613	93.52**
udatheac.	0	621	74.90**

** Significant at .01 level

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TABLE VIII

COMPARISON OF "the" COMBINATIONS

ORDINARY WORDS VERSUS NONSENSE WORDS

	Ordinary Word	Ord. Word Mean Time	Nonsense Word	Non. Word Mean Time	F-Score
#	them	470	thej	558	49.61**
#	then	465	thej	558	38.41**
#	they	458	thej	558	49.00**
	other	469	ithet	652	82.76**
#	neither	476	heitheg	751	110.07**
#	fathers	536	tathefs	690	42.05**
	fathers	536	fathead	586	12.37**
	fathead	586	tathefs	690	20.73**
	leathers,	532	meathead.	613	27.95**
	leathers,	532	udatheac.	621	19.57**
#	meathead.	613	udatheac.	621	0.19

\# Same-finger sequence

** Significant at the .01 level

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

The mean time for these four uses of "and" as a whole word was calculated as 472 units, and was compared to the time for the typing of each other use of the "and" combination occurring as part of longer words in the Nonsense Word portion of the copy. Table X shows the results of these comparisons. No significant difference was found for the word "demand." The word "handling" was typed significantly slower at the .05 level, and the other four words were significantly slower, at the .01 level.

Finally, the three matched pairs of ordinary and nonsense words were compared. Two had identical fingering patterns, and the other had the same sequence of right-and-left-hand strokes. In all three pairs, the ordinary word was typed significantly faster than the nonsense word, at the .01 level. Table XI shows these paired words.

<u>Summary</u>. Ten comparisons of three-letter combinations in actual, frequently-typed words were made with the same combinations appearing in non-English-language words. In every case the actual words were typed significantly faster than the nonsense words, at the .01 level. An additional four comparisons were made, pairing the "slang" words, "fathead" and "meathead," with actual words and with nonsense words. The comparison of the "slang" word "meathead." with the nonsense word "udatheac." did not show any significant difference. The actual words were typed significantly faster than the "slang" words, and "fathead" was typed significantly faster than the nonsense word "tathefs" -- all three of these at the .01 level.

TABLE IX

NONSENSE SECTION - "and" COMBINATIONS

USED IN TESTING HYPOTHESIS I

Word in Which Combination Used	Mean Time for 40 Subjects (Units)	Rank Order	Location (Line)
and	465	1	11
and	467	2	14-1
demand	475	3	14
and	478	4	14-2
and	480	5	15
understand	506	6	12
handling	532	7	13
ednand	545	8	11
undetsfand	546	9	14
jandkung	559	10	15
mean of "and"	472	-	4 cases

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

TABLE X

MEAN OF TIMES FOR "and" AS A WHOLE WORD
COMPARED TO OTHER "and" COMBINATIONS
IN NONSENSE WORD SECTION

Word	Frequency	Mean Time (Units)	F-Score
and	7,730	472	-
demand	64	475	0.15
ednand	0	545	34.04**
handling	50	532	6.51*
jandkung	0	559	38.85**
understand	55	506	13.41**
undetsfand	0	546	30.38**

* Significant at the .05 level
** Significant at the .01 level

TABLE XI

COMPARISON OF "and" COMBINATIONS

ORDINARY WORDS VERSUS NONSENSE WORDS

	Ordinary Word	Ord. Word Mean Time	Nonsense Word	Non. Word Mean Time	F-Score
#	demand	475	ednand	545	26.96**
	handling	532	jandkung	559	18.19**
#	understand	506	undetsfand	546	10.09**

\# Same-finger sequence

** Significant at the .01 level

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

TESTING OF HYPOTHESIS II

Hypothesis II states that there is no significant difference between the time required for the typing of frequently-typed three-letter combinations and similar three-letter combinations which are less frequently typed.

Here all the words used for comparison are three-letter words, of alternate-hand stroking patterns, in the Ordinary Word portion of the copy.

Comparisons Using "the" Combinations. All the three-letter combinations which make up whole words and use alternate-hand stroking patterns are listed in rank order of mean time for all 40 subjects typing the three-letter words. The information appears in Table XII. Six of the seven occurrences of "the" as a whole word are at the top of the list, having been typed more quickly than any of the other combinations. The seventh case, which is lower in the list, was found to be significantly slower at the .01 level when compared to each of the other six cases. The other six occurrences of "the" were also compared one to another, but no significant differences were found. The three occurrences of "for" were similarly compared, and also the two occurrences of "she." No significant differences were found.

For each subject, mean times were calculated for these multiple occurrences of "the," "for," and "she." The subjects'

TABLE XII

ORDINARY SECTION - "the" COMBINATIONS

USED IN TESTING HYPOTHESIS II

Word in Which Combination Used	Mean Time for 40 Subjects (Units)	Rank Order	Location (Line)
the	447	1	7
the	450	2	8
the	452	3	3
the	454	4	4
the	457	5	5-1
the	459	6	5-2
for	463	7	11
for	468	8	6
she	472	9	3
for	479	10	2
she	488	11	9
the	490	12	1
toe	495	13	8
rue	534	14	9
mean of "the"	458	-	7 cases
mean of "for"	470	-	3 cases
mean of "she"	480	-	2 cases

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]		[illegible]			[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]			[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

times for "toe" and "rue" and their mean times for "for" and "she" were compared to their mean time for typing "the." Results are shown in Table XIII. "The" was typed significantly faster than the more frequently typed words "for" and "she," at the .05 level, and faster than the less frequently typed words, "toe" and "rue," at the .01 level. As the frequency of use of the word decreased, the size of the difference increased.

Comparisons Using "and" Combinations. The combinations of "and" as a whole word and three other three-letter words which are of alternate-hand stroking patterns are shown in Table XIV. On the basis of their mean times all five cases of "and" as a whole word ranked in the top five positions in the list. The first "and," from Line 7, was typed in a significantly shorter time than any of the other four cases. The other four uses of "and" do not differ significantly from one another.

The mean time for these five "and" words was calculated for each subject, and was compared to the subjects' times for the other three-letter words. The results appear in Table XV. Not only was "and" typed significantly faster in each case, but as the frequency of use decreased the size of the difference increased.

Summary. The findings for the words "the" and "and" are similar. In each case the frequently-typed three-letter words were typed significantly faster than similar three-letter words

TABLE XIII

MEAN OF TIMES FOR "the" AS A WORD

COMPARED TO OTHER THREE-LETTER WORDS

IN ORDINARY WORD SECTION

Word	Frequency	Mean Time (Units)	F-Score
the	16,234	458	-
for	4,498	470	5.16*
she	59	480	7.17*
toe	1-3	495	12.14**
rue	0	534	41.66**

* Significant at the .05 level
** Significant at the .01 level

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[illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible]

[illegible] [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]
[illegible]

TABLE XIV

ORDINARY SECTION - "and" COMBINATIONS

USED IN TESTING HYPOTHESIS II

Word in Which Combination Used	Mean Time for 40 Subjects (Units)	Rank Order	Location (Line)
and	448	1	7
and	469	2	3
and	470	3	8
and	480	4	9
and	482	5	11
air	514	6	8
aid	514	7	11
ale	524	8	4
mean of "and"	470	-	5 cases

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]

TABLE XV

MEAN OF TIMES FOR "and" AS A WORD
COMPARED TO OTHER THREE-LETTER WORDS
IN ORDINARY WORD SECTION

Word	Frequency	Mean Time (Units)	F-Score
and	7,730	472	-
air	73	514	12.71**
aid	31	514	18.04**
ale	0	524	29.58**

** Significant at the .01 level

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

which are less frequently typed. Also, as the frequency of typing the word decreased, the size of the difference increased.

TESTING OF HYPOTHESIS III

Hypothesis III states that there is no significant difference between the time required to type common three-letter combinations occurring as separate words, and the time required for the same combinations occurring in longer words.

Comparisons Using "the" Combinations. All the three-letter "the" combinations used in testing Hypothesis III are listed in rank order of mean times for all 40 subjects. This information appears in Table XVI. The single mean time shown for the seven occurrences of "the" as a complete word included one "the" which was significantly slower than the other six. In the two occurrences of "they" the times for the "the" combinations were 44 units apart and were significantly different at the .01 level. Similarly in "their," the times for the "the" combinations were 45 units apart, significantly different at the .01 level. Therefore, any results involving these combinations of "the" in "they" and "their" must be viewed with caution.

The single mean time for the seven uses of "the" as a whole word was compared with the times for the "the" combinations appearing as parts of words of different lengths. The results of these comparisons are shown in Table XVII.

The word "the" was typed faster than any use of "the" as

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TABLE XVI

ORDINARY SECTION - "the" COMBINATIONS

USED IN TESTING HYPOTHESIS III

Word in Which Combination Used	Mean Time for 40 Subjects (Units)	Rank Order	Location (Line)
+ mean of "the"	458	1	7 cases
them	459	2	6
other	462	3	2
brother	466	4	5
they	466	5	8
their	467	6	10
smother	470	7	6
+ mean of "for"	470	8	3 cases
then	473	9	10
either	475	10	9
neither	475	11	5
mother	477	12	10
+ mean of "she"	480	13	2 cases
theme	496	14	7
blithe	499	15	3
they	510	16	9
their	512	17	9
theory	528	18	1
authentic	531	19	4
tithe	578	20	10
antithesis	608	21	3
mean of "they"	488	-	2 cases
mean of "their"	490	-	2 cases

+Times for the individual words included in these mean times are shown in Table XII

TABLE XVII

MEAN OF TIMES FOR "the" AS A WHOLE WORD

COMPARED TO OTHER "the" COMBINATIONS

IN ORDINARY WORD SECTION

Word	Frequency	Mean Time (Units)	F-Score
the	16,234	458	-
they	626	488	41.03**
them	460	459	0.00
then	178	473	5.32*
their	508	490	16.85**
other	498	462	0.49
theme	5	496	14.85**
tithe	1-3	578	67.47**
either	89	475	5.59*
theory	9	528	64.53**
mother	5	477	9.75**
blithe	0	499	12.74**
neither	12	475	2.35
brother	11	466	1.17
smother	0	470	3.09
authentic	1-3	531	25.64**
antithesis	0	608	72.38**

* Significant at the .05 level
** Significant at the .01 level

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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part of longer words. The difference was not significant with one four-letter word, one five-letter word, and all three seven-letter words. One four-letter word and one five-letter word were typed significantly slower at the .05 level, and nine other words of different lengths were significantly slower at the .01 level. Included in the words typed slower at the .01 level were "they" and "their," whose results, as mentioned earlier, must be viewed with caution. A comment might be added that in the Nonsense Word section a comparison of "the" as a whole word with the same letters in "they" showed a small, statistically insignificant, difference.

An interesting point should be noted. In three out of four five-letter words and in all four six-letter words there was a significant difference shown, but all three seven-letter words showed no significant difference. This surprising situation could not be accounted for by the frequency of use of the words, as the seven-letter words were infrequently used.

Comparison with "and" Combinations. As a verification of results obtained with the "the" combination, similar comparisons were made for the "and" combination occurring as a separate word and as part of words of different lengths.

All the three-letter "and" combinations used in testing Hypothesis III are listed in rank order of mean times for all 40 subjects. This information is given in Table XVIII. It should be recalled that one of the five uses of "and" as a whole word was typed significantly faster than the other four uses.

The single mean time for the five uses of "and" as a whole word was compared with the times for "and" three-letter combinations occurring as part of longer words. The results are given in Table XIX.

One four-letter word, one six-letter word, and one eight-letter word showed no significant difference in typing time. One seven-letter word showed a significant difference at the .05 level, and ten other words were typed significantly slower at the .01 level. These ten words included words of four to nine letters in length.

Summary. The instances of statistically significant differences for the comparisons of both "the" and "and" combinations are summarized in Table XX. The times for the 40 subjects on the three-letter combination occurring as a whole word are compared to the subjects' corresponding times for three-letter combinations appearing in different words.

Table XX shows that in twenty two cases there were significant differences, which would seem to indicate that the time required to type a "the" or "and" combination as part of a longer word was greater than the time required for the typing of the same three-letter combination occurring as a whole word. However, there were eight instances where there was no significant difference, and these cases appeared in words as long as eight letters in length.

TABLE XVIII

ORDINARY SECTION - "and" COMBINATIONS

USED IN TESTING HYPOTHESIS III

Word in Which Combination Used	Mean Time for 40 Subjects (Units)	Rank Order	Location (Line)
+mean of "and"	470	1	5 cases
remand	474	2	6
land	479	3	1
landlady	481	4	2
handy	488	5	2
landman	492	6	2
hand	497	7	10
landowner	499	8	1
handling	501	9	9
demand	501	10	6
bland	502	11	3
handles	505	12	1
handle	514	13	7
glandular	516	14	5
chandler	526	15	4

+Times for the individual words included in this mean time are shown in Table XIV

TABLE XIX

MEAN OF TIMES FOR "and" AS A WHOLE WORD

COMPARED TO OTHER "and" COMBINATIONS

IN ORDINARY WORD SECTION

Word	Frequency	Mean Time (Units)	F-Score
and	7,730	472	-
hand	90	497	9.01**
land	19	479	1.09
handy	11	488	7.29**
bland	0	502	9.94**
demand	64	501	8.13**
handle	51	514	12.50**
remand	0	474	0.24
handles	4	505	14.15**
landman	0	492	4.79*
handling	50	501	38.40**
chandler	0	526	28.10**
landlady	0	481	1.62
glandular	1-3	516	15.60**
landowner	0	499	8.34**

* Significant at the .05 level
** Significant at the .01 level

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TABLE XX

SUMMARY OF NON-SIGNIFICANT AND SIGNIFICANT DIFFERENCES

ORDINARY SECTION - "the" AND "and" COMBINATIONS

Length of Words	No. of "the" Combs.	No. of "and" Combs.	Not Sig. Diff.	Significantly Different .05 Level	Significantly Different .01 Level
4-letter	3		1	1	1#
4-letter		2	1	-	1
5-letter	4		1	-	3#
5-letter		2	-	-	2
6-letter	4		-	1	3
6-letter		3	1	-	2#
7-letter	3		3	-	-
7-letter		2	-	1	1
8-letter		3	1	-	2
9-letter	1		-	-	1
9-letter		2	-	-	2
10-letter	1		-	-	1
Totals	16	14	8	3	16 + 3#

#Some reason exists to doubt reliability of the result for one of these cases. Reasons are outlined in earlier comments

CHAPTER V

DISCUSSION OF RESULTS AND CONCLUSIONS

General Considerations. In addition to the changes in time for typing each three-letter group arising from the changes in context, there are other factors which must be considered in interpreting the results.

One evident factor is the amount of variation among individuals. The gross speeds ranged between approximately 50 and 60 words per minute, as determined by stop-watch timings. These gross speeds are, however, a form of average. A gross speed of 60 w.p.m. includes intervals of typing faster than 60, intervals of typing slower than 60, and lost time due to major hesitations, jammed keys, or other typing faults or delays. Some students maintain fairly steady speed with relatively small fluctuations, while others are erratic with many changes in their rate of typing. Indication of these variations can be seen in the standard deviation in times for each subject's strokes, as shown in Appendix G, Page 162. e.g. As shown in Table V, Page 54, Subjects 1.2 and 2.2 both took 174 seconds to type the 639 measured strokes in the entire copy, so each had the same gross speed. Subject 1.2 had a standard deviation of 64.34 units from his mean time of 190 units, while Subject 2.2 typed more steadily with a standard deviation of 52.48 from his mean time of 196 units per stroke.

These standard deviations show that there are variations between typists' performances which are not represented by a gross speed figure or by a mean time for making strokes. Two typists typing at the same gross speed do not type in the same manner throughout the copy.

In addition, one person's typing performance may vary considerably from time to time, even on the same strokes. Obviously the context in which the words are met will account for some of the difference, but so might a momentary tension, or a brief period of inattention, etcetera. For example, the degree of variation is indicated by Subjects 1.2 and 2.2 in their typing of the seven uses of "the" as a whole word. In Appendix E for Cards 53 and 57, Pages 145 and 149, Subject 1.2 took 379, 366, 489, 484, 406, 429, and 402 units of time. This gives a range of 123 units, or more than 33 per cent of the fastest typing of 366 units. Subject 2.2 was slower with 559, 502, 587, 617, 567, 570, and 586 units of time. The range is again high, 115 units, but the fastest typing of "the" by Subject 2.2 is slower than the slowest typing of the same whole word by Subject 1.2.

After noting the size of these time differences for typing "the" as a whole word, the size of the standard deviations for various three-letter combinations used in the analysis should also be considered. In Appendix F, Card 53, Page 155, the mean time for typing "the" from Line 7 of the copy is shown as 447 units.

The standard deviation for times of typing this word, however, is 61.97 units, which is approximately 14 per cent. This standard deviation figure indicates, generally, that approximately two thirds of the times for the 40 subjects will fall between 385.03 and 508.97 units, 61.97 units below and above the mean of 447. This gives a range of about 28 per cent for only two thirds of the subjects, still leaving about one third of the cases with times shorter or longer than these limits. This is a great amount of spread, in relation to the approximately 10 per cent of spread in gross speed. Yet such spreads of standard deviations are quite common with these subjects' times.

The relatively small amount of spread in mean time from all 40 subjects' times for typing different three-letter combinations is also noteworthy. Appendix F, Card 53, Page 155, shows that the slowest typing of "the" as a whole word took a mean time of 490 units. This is 31 units slower than the next slowest time for typing the same word, but this is enough difference to be significant. Yet the smallest standard deviation for any of the seven uses of "the" as a whole word is 54.23 units, appreciably higher than a significant spread of mean times.

The method of statistical analysis used attempts to eliminate the variations among individuals, and also the experimental error, thereby leaving for analysis the differences arising from a change in context or "treatment." This has apparently been done, but in interpreting the results one must realize that the

amount of difference apparently arising from change in context is not large in relation to the ordinary ups-and-downs of any typist's performance, nor in relation to variations between subjects who are typing at the same rate of gross speed.

It would have been possible to obtain a better understanding of how much variation there is within one individual's performance if all or part of the copy had been retyped and measured again. From this a good indication of consistency could have been obtained. However, this was not done. There were, nevertheless, several words which occurred more than once, and while these did not appear in exactly parallel context they do give an indication of consistency. The words which were repeated are shown in Table XXI, with indications whether the times for typing the three-letter group altered significantly, or whether they remained consistent enough to be statistically insignificant.

Out of twenty uses of "the" and "and" as whole words, three were found significantly different from the others in typing time. Out of nine other pairs of words which appeared more than once, six pairs showed no significant difference, but three showed significantly different times for one of the pair.

These results clearly imply that caution must be exercised in generalizing from the times for typing any three-letter combination which has been typed and measured only once. As many of the words being used for analysis were measured only once, generalizations can only be made if several such cases confirm the findings.

TABLE XXI

SUMMARY OF WORDS APPEARING MORE THAN ONCE

SHOWING WHETHER DIFFERENCES ARE SIGNIFICANT OR NOT SIGNIFICANT

FOR TIME OF TYPING "the" OR "and" COMBINATION

Word	Number Cases in Ordinary Section	Number Cases in Nonsense Section	Significantly Different	Not Significantly Different
the	7	-	1	6
the	-	4	1	3
and	5	-	1	4
and	-	4	-	4
the	1 (mean of 7)	1 (mean of 4)	-	2
and	1 (mean of 5)	1 (mean of 4)	-	2
for	3	-	-	3
she	2	-	-	2
their	2	-	1	1
they	2	-	1	1
they	1 (mean of 2)	1	1	1
them	1	1	-	2
then	1	1	-	2
demand	1	1	1	1
other	1	1	-	2
neither	1	1	-	2

<u>Conclusions for Hypothesis I</u>. This hypothesis compared the time required for typing of frequently-typed three-letter combinations appearing in actual words with the time for typing the same combinations appearing in non-English-language words of similar stroking patterns.

The stroking patterns were kept as parallel as possible, so that the change in context would be small. In eight of the comparisons the exact sequence of finger use was maintained, and in the other six comparisons the same sequence of right-and-left-hand motions was maintained. Any differences in typing speed arising from the physical difficulties of stroking should be very small.

The largest part of any differences observed would arise from patterning of strokes, and for the nonsense words the previous opportunities to develop patterns would be zero. Without any patterning the typing would be on a "stroke response" level. If patterns of stroking are formed as a result of typing familiar words, ordinary English-language words should be typed more quickly than the nonsense words, and it could be inferred that a "word response" level of typing had indeed been developed on the familiar words.

Even within the nonsense words the combinations of "the" or "and" which were being timed for these comparisons might be familiar enough to be typed on a letter-combination level of word-response typing, by some subjects. If the differences were great enough to be significant, overriding any such partial word

response typing in the nonsense words, the existence of a word-response level of typing would be even more conclusively demonstrated.

The comparisons of fourteen matched pairs of actual and nonsense words showed significantly faster times for typing of the "the" or "and" combination in the actual word, with one exception. The comparison of the "slang" word "meathead." with the nonsense word "udatheac." showed a non-significant difference. However, uncommon "slang" words such as "meathead." are similar to nonsense words since it is unlikely that any of the subjects would have typed this word with enough frequency to develop patterns of typing it.

On the basis of these findings, Hypothesis I is rejected. It appears that there is a significant difference between the time required for the typing of frequently-typed three-letter combinations when they appear in actual frequently-typed words, and the time required when they appear in non-English-language words of similar stroking patterns. It appears that word response typing does exist in the typing of three-letter combinations.

<u>Conclusions for Hypothesis II</u>. The primary factor in testing this Hypothesis is the frequency of meeting and typing the words. If the level of typing skill is higher for words which are frequently typed, and lower for words which are less frequently typed, this would indicate that word-response patterning of strokes improves

with frequency of typing a word. Obviously there is a physical limit to such improvement.

Another factor which varies within the several three-letter words used is the stroking pattern of the words themselves. These variations were minimized by keeping the words as parallel to "the" and "and" as possible. All words use alternate-hand stroking. The word "rue" uses the exact sequence of finger movements as "the." "She" and "toe" have two letters in common with "the," and so does "aid" with "and." There is little reason to think that the physical difficulty of stroking any one of these words would be appreciably greater than for any other.

The time for typing each of four similar words was compared with the time for typing "the" as a whole word, and also the time for typing each of three similar words was compared with the time for typing "and" as a whole word. In all seven comparisons "the" or "and" were typed significantly faster and, in each series of comparisons, as the frequency of use of the word decreased the size of the difference increased.

On the basis of these findings, Hypothesis II is rejected. It appears that there is a significant difference between the time required for the typing of frequently-typed three-letter combinations and similar three-letter combinations which are less frequently typed.

It is interesting to note that while comparison of speed of typing these words shows significant differences, the

differences in mean speed for the 40 subjects were not large. "For" had a mean time of 470 units, only 12 units slower than "the," and the percentage of difference is only 2.6 per cent. Even "toe," with its very infrequent occurrences was only 8.1 per cent slower than "the," and "rue" with zero occurrences was 16.6 per cent slower. The word "ale" also showed a frequency of zero occurrences and was only 11.0 per cent slower than "and."

These figures indicate that the gains to be obtained from word-response typing of short words are not particularly large, after a word has been typed a few times.

<u>Conclusions for Hypothesis III</u>. In testing this hypothesis, the major variant is the length of the words within which the three-letter combination occurs. Most of the words had alternate-hand stroking for the letters immediately before and after the measured three-letter combination, and some had alternate-hand stroking throughout. However, especially with longer words the physical ease of typing the preceding strokes, the three-letter combination, and the following strokes may not be equivalent. The physical difficulty of transitional movements into the three-letter combination and out of it is probably different in some cases.

Only a single timing was available for most of these words, which leaves doubt as to whether the typing of any once-typed word was a "typical" performance. It will be remembered, as mentioned on Page 89, that two typings of the words "they"

and "their" showed significantly different times for the three-letter "the" combination within them. Comparisons using the mean times for the two occurrences of these two words are to be interpreted with care; likewise, comparisons using those words which were typed only once must also be viewed with caution.

The words used in these comparisons are also met with varying frequency. For example, the eight-letter word "handling" has a frequency of 50 uses, compared to 90 for the four-letter word "hand," and 19 for the other four-letter word, "land." The words "bland" and "landlady" showed zero uses, but both have the "land" combination which has been met in some other words. The conclusion for Hypothesis II showed that the frequency of typing a word can affect the time of typing some combinations within the word.

Another uncontrolled factor is the location of the "the" or "and" combination within the longer word. In "theory" and some other words the three-letter combination begins the word. In "blithe" and "tithe" it ends the word. In other words, the three-letter combination appears in various positions within the word, and these changes in location within the word introduce an uncontrolled factor of difference.

The results of comparisons of "the" or "and" as whole words with the same three-letter combinations appearing as parts of longer words were shown in Tables XVII and XIX, on Pages 91 and 95. There is little consistency in the results shown with

differing lengths of words. In eight of the thirty comparisons there was no significant difference in the time for typing the three-letter combination as a whole word or as part of a longer word. In these eight comparisons there was at least one word of four, five, six, seven, or eight letters in length, and, in fact, all three of the seven-letter words compared with "the" as a whole word showed no significant difference. In the other twenty-two comparisons, however, there was a significant difference showing faster typing of "the" or "and" as a whole word.

In the light of these comparisons, it is impossible to conclude that there is no significant difference between the time required to type common three-letter combinations occurring as separate words, and the time required for the same combinations occurring in longer words. Therefore, Hypothesis III cannot be accepted. Neither, however, can this Hypothesis be conclusively rejected. Although the weight of evidence favors such a rejection, the inconsistency of the time comparisons indicates that Hypothesis III must be left as unresolved.

It appears that if there are differences arising from the length of the words within which the three-letter combinations are included, the differences are obscured or concealed by the other factors operating concurrently.

CHAPTER VI

IMPLICATIONS AND RECOMMENDATIONS

Although this study was limited in the number and experience of the typists measured, and in the three-letter combinations and words used for analysis, several implications emerge:

1. The study confirms the existence of a word-response form of typing at a three-letter level. This level is not necessarily a limit, and further studies might or might not indicate the existence of higher levels of word-response typing.
2. The study confirms previous opinions that frequency of typing a word or combination will assist in developing some form of patterning of strokes which will give an advantage in speed. However, there is some indication that a great many repetitions of typing certain three-letter words do not offer large percentage gains in speed. The most frequently-typed words were typed only about ten per cent faster than rather infrequently-typed words of similar stroking patterns.
3. Quantitative measurements of the individual strokes may offer a useful research approach for the study of typewriting problems. A particularly important factor is that with the advent of computers a large quantity of numerical data can be processed and analyzed with relative

ease. This can overcome a major obstacle, which may have restricted the use of this graphic-recording attack as a research method during recent years.

5. It would appear that students late in their second year of typewriting would be suitable subjects for research into somewhat higher levels of word-response typing than the three-letter level analyzed in this study.

RECOMMENDATIONS

The following recommendations are suggested for those who may be interested in continuing or improving this fine-timing approach to typewriting research:

1. If graphic recording is to be widely used as a research tool for typewriting, a more efficient way of measuring time for a stroke should be devised. The method used here of individual measurements with a hand-scale proved too slow and tedious for widespread application. It seems probable that in the present stages of technology some form of electronic measurement could be arranged which would produce data in a form directly suitable for computer use. If this could be done, the graphic record itself would only be necessary as a visual check on the accuracy and reasonableness of the recorded times.
2. In any study similar to this one, at least a portion of the copy should be repeated, to test the consistency of

typing patterns. The Odell study and the studies by Vandegrift and McMillon apparently started something like this, but neither study was published in final form. The opportunity was overlooked in this study.

3. Studies of four-letter, five-letter, etcetera, combinations could be made to investigate further the development of word-response typing, and the size of possible gains obtainable from patterning of strokes at these higher levels.
4. Studies should be undertaken to investigate the development of word-response typing throughout the learning period. Bi-weekly checks could indicate when words of different frequency and length become automatized into word-response patterns.
5. Pre-test and post-test time recordings could be used to assess the effectiveness of various instructional procedures.
6. Time-recording studies could be made on relatively rare and slowly-typed words, like "rue" in this study, to see how much practice would be needed to hasten the development of word-response patterns. After an interval of weeks or months without practicing the word, the retention of the word-response pattern could be re-tested. From this we might learn the value of school practice on

specialized business vocabulary which might not be used for a considerable period of time after being learned in school.

7. There would be value in continuing Vandegrift and McMillon's use of graphic recording as a motivational device and as a means of isolating an individual's typewriting weaknesses. However, such uses would be contingent on having apparatus which was inexpensive and easy to use, and recordings which were easy to measure.

8. Further study of practical typing operations in business offices would be useful, to see what refinements are developed for production tasks such as: billing; transcription from shorthand, dictating machine, or voice; typing from rough drafts; typing multiple copies; etcetera.

9. Time-recording apparatus could be very useful in setting up standards of accomplishment for various tasks or portions of tasks, such as envelope addressing, paper insertion, etcetera, both in schools and in offices.

10. Similar time-recording studies should be appropriate for studying the operation of business machines, such as adding machines, calculators, and key punch machines. Research studies on business machine operation have been rare compared with research studies on typewriting.

11. The use of slow-motion photography concurrent with minutely-timed recordings might add a very illuminating perspective to the studies suggested here.

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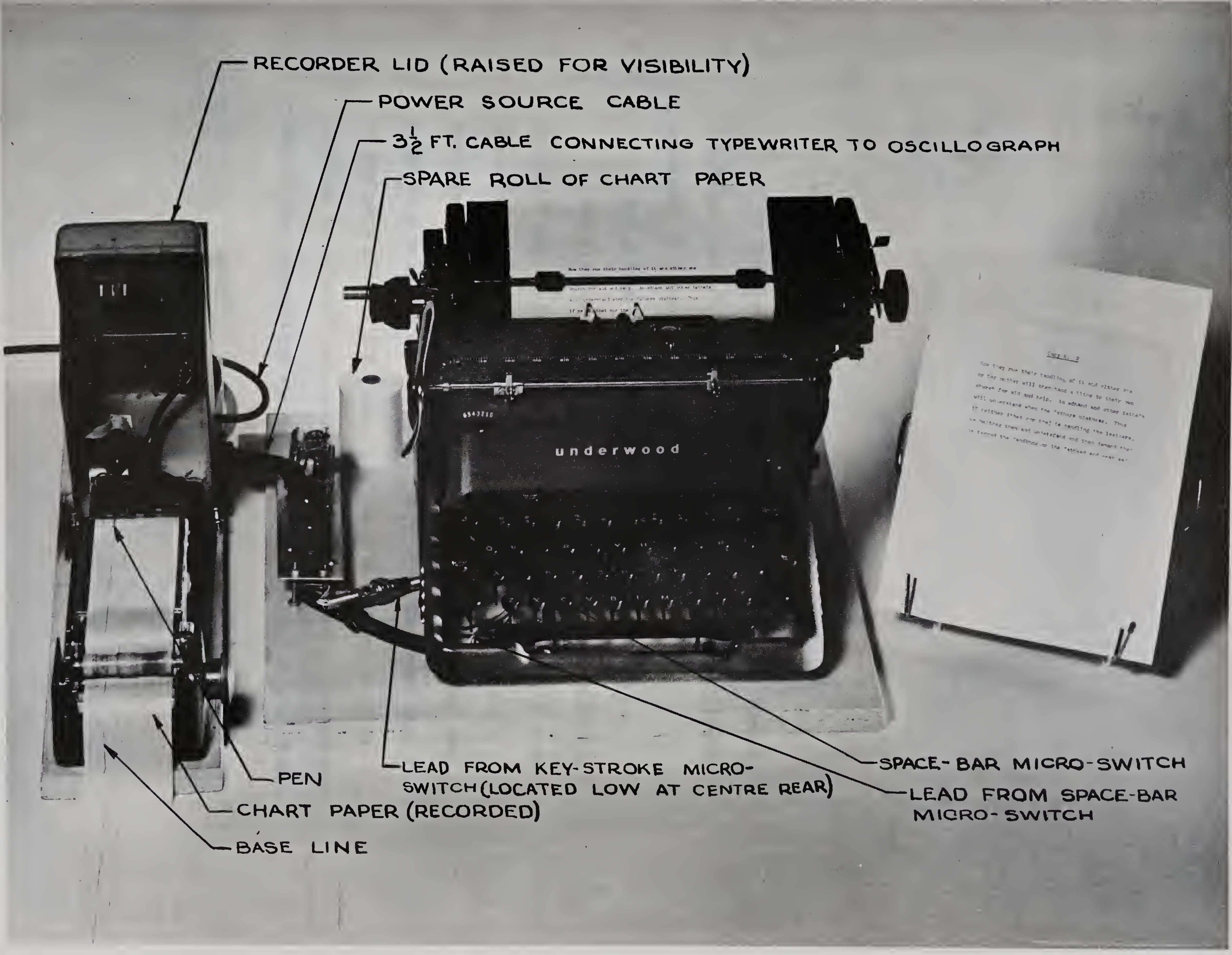
APPENDICES

APPENDIX A

PHOTOGRAPH OF RECORDING APPARATUS


RECORDER LID (RAISED FOR VISIBILITY)
POWER SOURCE CABLE
3½ FT. CABLE CONNECTING TYPEWRITER TO OSCILLOGRAPH
SPARE ROLL OF CHART PAPER
underwood
PEN
CHART PAPER (RECORDED)
BASE LINE
LEAD FROM KEY-STROKE MICRO-SWITCH (LOCATED LOW AT CENTRE REAR)
SPACE-BAR MICRO-SWITCH
LEAD FROM SPACE-BAR MICRO-SWITCH

APPENDIX B

WIRING DIAGRAM FOR OSCILLOGRAPH RECORDING

The three micro-switches, labelled "All Keys," "Space," and "Upper Case," are shown in their normal positions before operation of a key, etcetera, closed the switch.

The points marked A-1 and A-2 are Relay Contacts.

The micro-switch labelled "Upper Case" was attached to the shift key of the typewriter, and recorded the moment when the shift key was depressed. When the connection was made, the current went through a Relay Coil, and the recording pen moved only half the usual distance away from the "base line," on the same side of the "base line" as ordinary key strokes. Although these shift key operations were recorded on the graphic record, the information was not used in analyses for this study.

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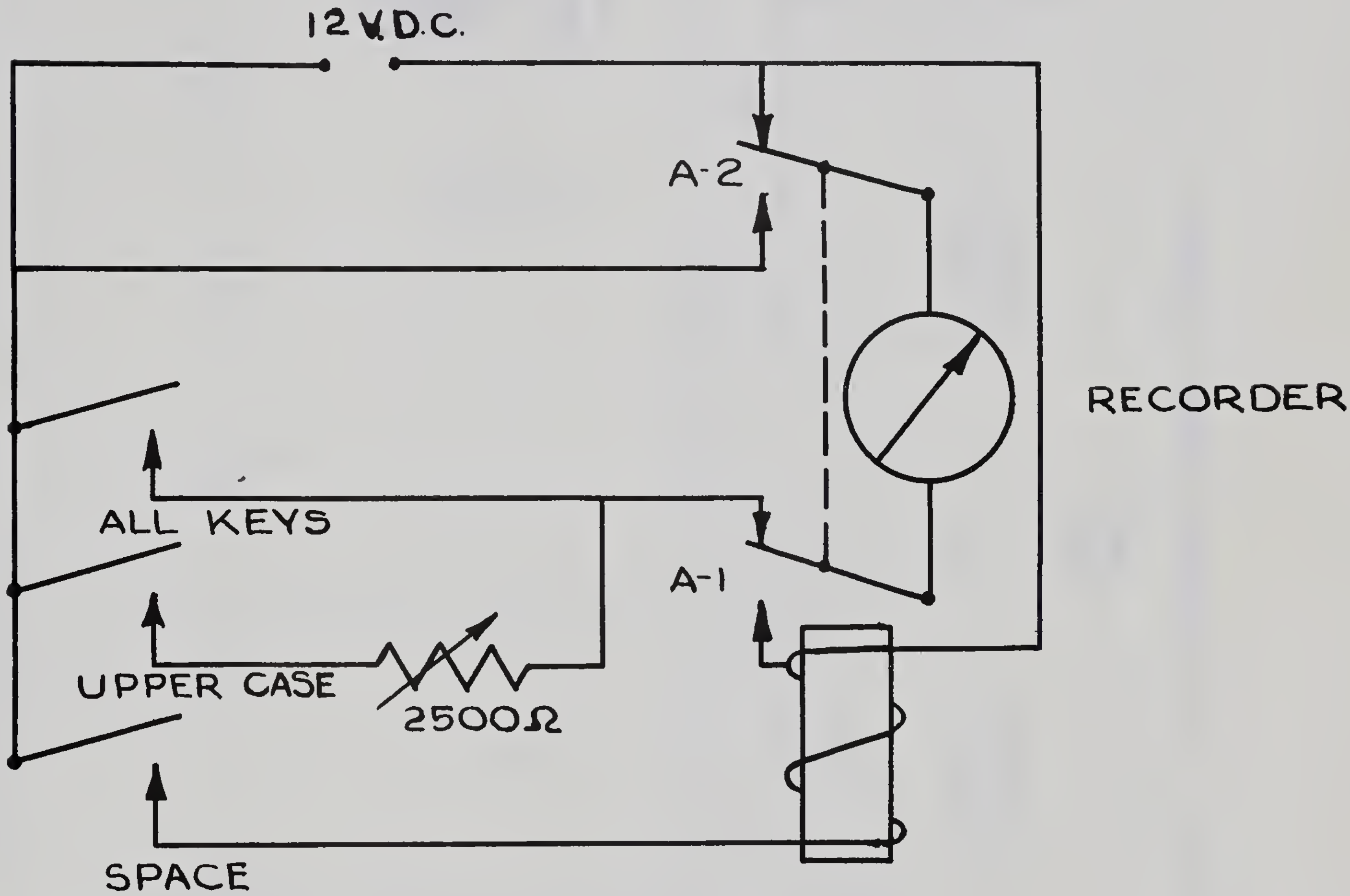
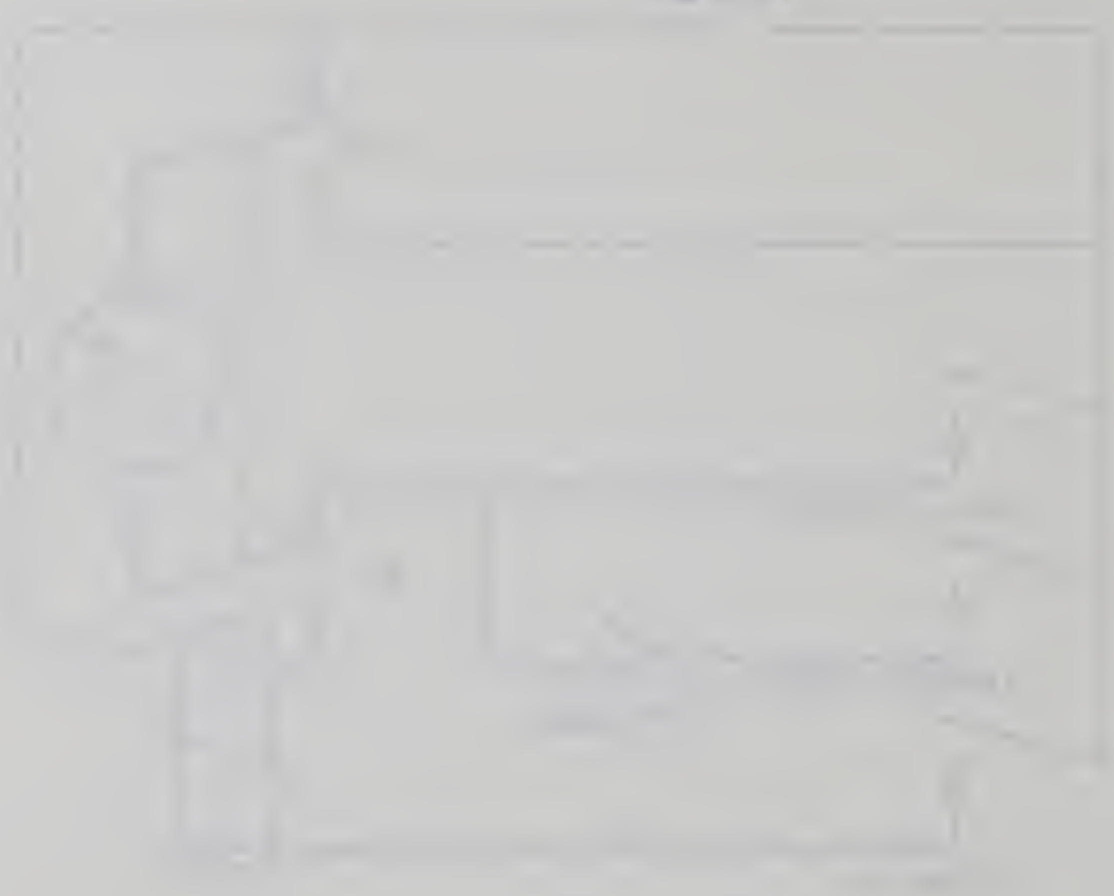
APPENDIX B

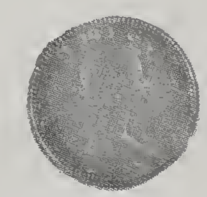
WIRING DIAGRAM FOR OSCILLOGRAPH RECORDING
from
MICRO-SWITCHES OPERATED BY TYPEWRITER STROKES



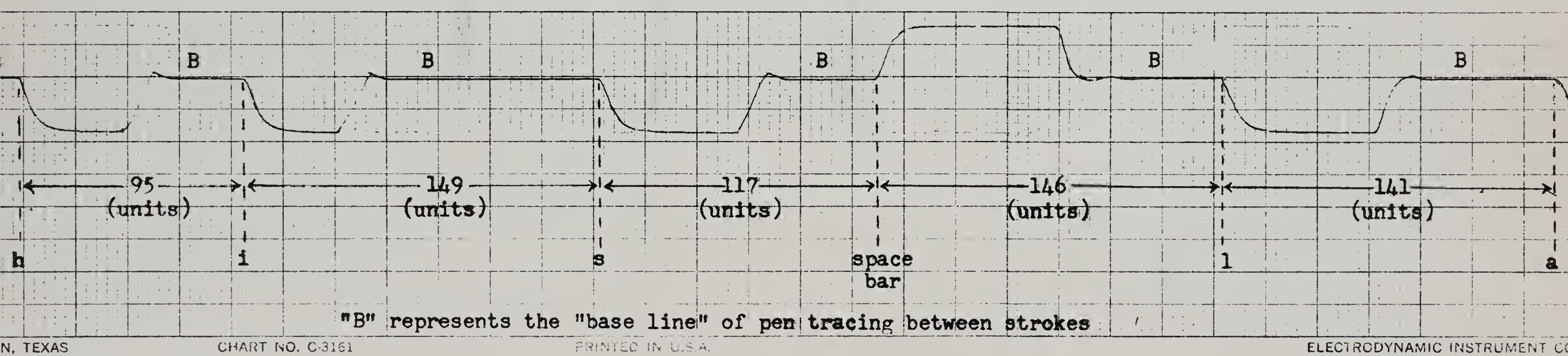


APPENDIX C

MEASUREMENT SCALE -- AND STRIP OF RECORDED CHART PAPER SHOWING KEY STROKES, SPACE BAR STROKE, LETTERS STRUCK, AND MEASUREMENT OF INTERVALS BETWEEN STROKES



Dime, for size comparison



APPENDIX D

MEAN, VARIANCE, AND STANDARD DEVIATION

and

NUMBER OF STROKES ADJUSTED TO MEAN

FOR ALL RECORDED KEY STROKES

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 1, LINE 1

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	7060.	177	936.15	30.59	0
T	7691.	192	1537.55	39.21	1
H	6181.	155	538.70	23.20	0
E	7228.	181	719.91	26.83	4
O	8046.	201	2656.97	51.54	4
R	7391.	185	1742.67	41.74	3
Y	7723.	193	1768.47	42.05	3
*	7137.	178	1539.09	39.23	0
T	7007.	175	998.74	31.60	1
H	6008.	150	878.56	29.64	1
E	6567.	164	827.39	28.76	2
*	5522.	138	951.79	30.85	1
L	7600.	190	1019.35	31.92	1
A	6003.	150	612.97	24.75	1
N	7015.	175	702.98	26.51	2
D	6933.	173	1265.12	35.56	1
O	9146.	229	2394.72	48.93	9
W	7589.	190	1296.15	36.00	6
N	7895.	197	1698.38	41.21	4
E	6991.	175	1228.87	35.05	2
R	6972.	174	602.81	24.55	1

RECORDING SHEET 2, LINE 1

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6248.	156	792.31	28.14	0
H	7599.	190	908.62	30.14	0
A	5939.	148	865.10	29.41	0
N	7077.	177	871.82	29.52	2
D	7200.	180	1093.55	33.06	10
L	6931.	173	1255.85	35.43	5
E	6796.	170	1537.24	39.20	1
S	7275.	182	473.96	21.77	2
*	5966.	149	975.82	31.23	0
H	7440.	186	1001.05	31.63	0
I	6865.	172	438.53	20.94	0
S	6154.	154	833.52	28.87	1
*	5735.	143	725.48	26.93	0
L	7269.	182	1116.15	33.40	2
A	6043.	151	834.57	28.88	5
N	6546.	164	640.97	25.31	5
D	6571.	164	877.25	29.61	0
*	5501.	138	1208.95	34.76	2

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 3, LINE 2

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6752.	169	601.46	24.52	3
L	7603.	190	753.82	27.45	4
A	6027.	151	303.27	17.41	7
N	6868.	172	1245.06	35.28	5
D	6767.	169	562.79	23.72	2
M	9076.	227	2910.59	53.94	4
A	6656.	166	408.09	20.20	2
N	6894.	172	1047.22	32.36	2
*	6221.	156	754.55	27.46	1
F	6812.	170	1914.16	43.75	1
O	6131.	153	383.60	19.58	1
R	6227.	156	587.92	24.24	1
*	5210.	130	680.08	26.07	0
H	7565.	189	874.41	29.57	0
A	5930.	148	633.83	25.17	1
N	6893.	172	592.67	24.34	3
D	6714.	168	761.47	27.59	3
Y	7314.	183	1366.67	36.96	1
*	6540.	164	507.70	22.53	0

RECORDING SHEET 4, LINE 2

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
T	17721.	443	10835.62	104.09	2
H	10225.	256	7852.73	88.61	0
E	6644.	166	788.84	28.08	3
I	6800.	170	1080.10	32.86	2
R	6157.	154	699.52	26.44	1
*	5531.	138	770.80	27.76	2
O	7987.	200	2164.97	46.52	0
T	6510.	163	411.33	20.28	1
H	5915.	148	434.66	20.84	1
E	6040.	151	564.15	23.75	0
R	6687.	167	443.29	21.05	0
*	6207.	155	871.24	29.51	1
L	7852.	196	1882.51	43.38	3
A	6011.	150	535.80	23.14	4
N	6599.	165	659.32	25.67	4
D	6615.	165	1280.78	35.78	2
L	8189.	205	2969.05	54.48	3
A	6570.	164	689.73	26.26	4
D	10273.	257	5556.09	74.53	8
Y	7354.	184	1447.67	38.04	7

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 5, LINE 3

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6201.	155	1419.82	37.68	1
T	6052.	151	258.41	16.07	4
H	5967.	149	603.09	24.55	1
E	6047.	151	849.94	29.15	4
*	5891.	147	946.65	30.76	5
A	7119.	178	884.87	29.74	2
N	6705.	168	1758.53	41.93	2
T	7775.	194	2211.63	47.02	4
I	7252.	181	855.01	29.24	2
T	7712.	193	1704.06	41.28	6
H	8142.	204	3089.39	55.58	3
E	8481.	212	3385.37	58.18	2
S	8491.	212	1521.75	39.00	4
I	8187.	205	2295.72	47.91	6
S	6692.	167	1380.96	37.16	5
*	6066.	152	806.02	28.39	0
O	8246.	206	1833.82	42.82	1
F	6045.	151	528.21	22.98	0
*	5609.	140	844.82	29.06	0

RECORDING SHEET 6, LINE 3

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
B	9249.	231	3612.42	60.10	4
L	7086.	177	915.32	30.25	6
A	6468.	162	1425.91	37.76	5
N	6881.	172	697.02	26.40	7
D	6723.	168	923.92	30.39	9
*	6156.	154	1316.59	36.28	5
A	6649.	166	782.87	27.97	2
N	6137.	153	724.44	26.91	1
D	5982.	150	528.59	22.99	1
*	5482.	137	1119.24	33.45	1
B	8560.	214	2947.00	54.28	2
L	7767.	194	4921.09	70.15	5
I	7928.	198	1418.96	37.66	6
T	6957.	174	772.22	27.78	2
H	6264.	157	879.94	29.66	2
E	6721.	168	1145.67	33.84	2
*	6487.	162	1002.39	31.66	6

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 7, LINE 3

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
W	7161.	179	1141.67	33.78	4
H	5795.	145	420.41	20.50	3
E	6096.	152	488.59	22.10	1
N	6469.	162	462.10	21.49	2
*	6058.	151	764.99	27.65	1
S	6600.	165	911.75	30.19	6
H	6044.	151	792.34	28.14	3
E	6243.	156	773.02	27.80	2

RECORDING SHEET 8, LINE 4

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6185.	155	1079.28	32.85	1
A	8583.	215	3523.74	59.36	2
U	7483.	187	1968.67	44.36	4
T	7932.	198	2428.91	49.28	2
H	6346.	159	1218.27	34.90	0
E	6958.	174	874.64	29.57	3
N	6999.	175	951.87	30.85	3
T	7703.	193	1636.64	40.45	5
I	6802.	170	1039.84	32.24	1
C	7324.	183	1143.49	33.81	2
*	6713.	168	686.09	26.19	3
A	7768.	194	2180.76	46.69	2
L	6363.	159	645.97	25.41	1
E	6845.	171	516.01	22.71	7
*	6202.	155	1247.89	35.32	6
I	7495.	187	892.18	29.86	2
N	7624.	191	980.84	31.31	2
*	6271.	157	624.97	24.99	3

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 9, LINE 4

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
T	6484.	162	534.44	23.11	1
H	5578.	139	595.79	24.40	0
E	6086.	152	630.57	25.11	1
*	5400.	135	632.15	25.14	1
C	8104.	203	2917.89	54.01	3
H	6364.	159	881.39	29.68	6
A	6672.	167	520.76	22.82	5
N	6972.	174	560.51	23.67	3
D	7393.	185	1991.04	44.62	11
L	7317.	183	1334.07	36.52	6
E	6794.	170	778.67	27.90	7
R	7277.	182	1220.17	34.93	10
*	6073.	152	855.09	29.24	5
S	7087.	177	1506.14	38.80	7
H	5956.	149	745.24	27.29	3
O	8831.	221	3926.77	62.66	3
P	7821.	196	1118.35	33.44	1
.	12694.	317	7037.78	83.89	4
*	9007.	225	1639.69	40.49	3
*	6557.	164	910.42	30.17	0

RECORDING SHEET 10, LINE 5

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6098.	152	1224.79	34.99	3
N	9776.	244	5081.54	71.28	4
E	7277.	182	2159.27	46.46	12
I	6757.	169	1377.22	37.11	4
T	6928.	173	2126.36	46.11	3
H	6085.	152	1020.11	31.93	0
E	5977.	149	683.19	26.13	0
R	6553.	164	506.34	22.50	0
*	6050.	151	1151.98	33.94	0
T	6617.	165	769.04	27.73	0
H	5907.	148	955.72	30.91	0
E	5749.	144	555.55	23.57	1
*	5744.	144	883.09	29.71	1
B	6724.	168	675.94	25.99	2
R	9927.	248	2813.79	53.04	4
O	7244.	181	1296.09	36.00	4
T	6512.	163	543.31	23.30	4
H	6097.	152	907.04	30.11	2
E	6012.	150	854.66	29.23	0
R	6754.	169	768.52	27.72	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 11, LINE 5

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6057.	151	1543.74	39.29	1
N	7832.	196	970.26	31.14	1
O	7089.	177	995.82	31.55	5
R	6717.	168	1425.07	37.75	6
*	6271.	157	1112.37	33.35	1
T	6457.	161	1008.14	31.75	1
H	5845.	146	590.81	24.30	2
E	6042.	151	616.49	24.82	3
*	5837.	146	1031.92	32.12	2
G	8074.	202	2755.02	52.48	7
L	7817.	195	2905.44	53.90	4
A	6609.	165	917.72	30.29	1
N	6919.	173	573.07	23.93	1
D	7097.	177	1543.34	39.28	5
U	8258.	206	1833.59	42.82	1
L	8484.	212	1742.89	41.74	4
A	6495.	162	1790.68	42.31	7
R	7793.	195	1662.54	40.77	4
*	6018.	150	705.44	26.56	1

RECORDING SHEET 12, LINE 6

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6582.	165	1373.09	37.05	2
S	7435.	186	2598.41	50.97	1
M	6846.	171	833.87	28.87	1
O	7922.	198	1961.94	44.29	3
T	6704.	168	795.04	28.19	4
H	5993.	150	369.84	19.23	3
E	6119.	153	725.57	26.93	2
R	6546.	164	418.57	20.45	3
*	5910.	148	695.03	26.36	2
A	7184.	180	1052.49	32.44	3
N	6097.	152	486.99	22.06	2
Y	9509.	238	2179.05	46.68	3
*	7161.	179	651.17	25.51	3
D	7358.	184	2454.29	49.54	2
E	8227.	206	848.42	29.12	1
M	6714.	168	1021.87	31.96	1
A	6397.	160	553.32	23.52	2
N	6744.	169	1208.49	34.76	1
D	6894.	172	2297.32	47.93	4

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 13, LINE 6

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	5967.	149	1036.69	32.19	1
T	6765.	169	1105.21	33.24	1
H	5614.	140	607.87	24.65	0
E	6115.	153	858.36	29.29	0
R	6724.	168	690.34	26.27	2
E	7146.	179	527.02	22.95	4
*	6167.	154	1284.84	35.84	1
I	7575.	189	936.88	30.60	0
S	5968.	149	776.71	27.86	2
*	5735.	143	625.28	25.00	2
T	6608.	165	791.66	28.13	0
O	6054.	151	983.92	31.36	0
*	6427.	161	608.97	24.67	0
R	7135.	178	760.53	27.57	0
E	6753.	169	690.29	26.27	3
M	6779.	169	801.60	28.31	0
A	6030.	151	519.13	22.78	1
N	6656.	166	804.44	28.36	3
D	6280.	157	885.55	29.75	3

RECORDING SHEET 14, LINE 6

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	5760.	144	585.50	24.19	0
T	6662.	167	759.44	27.55	1
H	5626.	141	770.37	27.75	0
E	6057.	151	524.09	22.89	1
M	6912.	173	589.06	24.27	3
*	6783.	170	997.09	31.57	3
F	6680.	167	455.50	21.34	6
O	5889.	147	411.27	20.27	6
R	6164.	154	957.34	30.94	6

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 15, LINE 7

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	5736.	143	748.94	27.36	0
T	6987.	175	1251.17	35.37	2
H	5954.	149	822.52	28.67	0
E	7317.	183	1953.87	44.20	6
F	10157.	254	4196.62	64.78	4
T	8927.	223	621.79	24.93	2
*	6447.	161	1044.34	32.31	0
O	7779.	194	1332.20	36.49	1
F	5866.	147	579.47	24.07	2
*	5742.	144	693.64	26.33	1
T	6132.	153	631.16	25.12	0
H	5745.	144	697.73	26.41	1
E	6013.	150	819.22	28.62	2
*	5711.	143	916.82	30.27	2
T	7076.	177	1481.44	38.48	3
H	6196.	155	669.24	25.86	6
E	6583.	165	580.34	24.09	4
M	7126.	178	1500.82	38.74	7
E	6765.	169	311.56	17.65	5

RECORDING SHEET 16, LINE 7

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6639.	166	1407.07	37.51	8
T	7157.	179	1055.82	32.49	5
O	6332.	158	1222.21	34.96	3
O	6513.	163	976.84	31.25	0
.	10266.	257	1730.02	41.59	3
*	8531.	213	1603.95	40.04	0
*	6645.	166	950.46	30.82	0
W	18022.	451	9523.45	97.58	2
E	10758.	269	2116.54	46.00	2
*	6077.	152	933.57	30.55	2
H	8271.	207	1558.57	39.47	1
A	6175.	154	766.38	27.68	1
N	6987.	175	779.02	27.91	2
D	7403.	185	2286.27	47.81	8
L	7396.	185	1836.69	42.85	3
E	7133.	178	1740.77	41.72	4
*	5864.	147	666.09	25.80	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 17, LINE 7

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
T	6581.	165	1039.05	32.23	2
H	5581.	140	637.60	25.25	1
E	6240.	156	564.70	23.76	8
S	7837.	196	1140.32	33.76	4
E	7310.	183	358.18	18.92	2
*	5948.	149	828.31	28.78	1
A	6330.	158	624.08	24.98	3
N	6136.	153	523.19	22.87	1
D	5463.	137	846.24	29.09	2

RECORDING SHEET 18, LINE 8

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6412.	160	1549.76	39.36	3
T	6810.	170	904.18	30.06	3
H	5805.	145	880.26	29.66	1
E	6016.	150	883.94	29.73	1
Y	6363.	159	1106.32	33.26	2
*	6884.	172	1349.79	36.73	0
G	7041.	176	1174.67	34.27	1
A	7305.	183	1401.88	37.44	1
T	7508.	188	1334.91	36.53	0
H	6597.	165	886.67	29.77	2
E	6266.	157	583.37	24.15	2
R	6281.	157	435.52	20.86	1
*	6420.	161	1145.40	33.84	0
A	7125.	178	937.06	30.61	5
I	7131.	178	1429.55	37.80	5
R	6288.	157	939.96	30.65	5
*	6141.	154	863.45	29.38	0
A	6800.	170	639.20	25.28	2
T	7587.	190	884.27	29.73	4

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 19, LINE 8

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6100.	153	763.05	27.62	1
T	6224.	156	864.34	29.39	0
H	6060.	152	687.05	26.21	0
E	5705.	143	711.58	26.67	2
*	5658.	141	672.19	25.92	2
T	6249.	156	753.22	27.44	3
O	6677.	167	1048.87	32.38	1
E	6888.	172	1956.36	44.23	4
*	5962.	149	579.89	24.08	1
A	6711.	168	1189.37	34.48	2
N	6203.	155	633.77	25.17	0
D	5876.	147	982.14	31.33	0
*	5263.	132	1026.04	32.03	0

RECORDING SHEET 20, LINE 9

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6952.	174	2127.76	46.12	0
T	7490.	187	713.53	26.71	0
H	6253.	156	724.42	26.91	0
E	6668.	167	614.61	24.79	0
Y	6836.	171	1148.94	33.89	0
*	7352.	184	2005.31	44.78	0
R	7697.	192	1889.59	43.46	1
U	6881.	172	1622.52	40.28	2
E	6777.	169	774.04	27.82	2
*	6244.	156	1004.74	31.69	2
T	7254.	181	1453.52	38.12	1
H	6138.	153	774.34	27.82	1
E	7091.	177	702.70	26.50	1
I	7172.	179	1495.71	38.67	2
R	6885.	172	809.96	28.45	0
*	6317.	158	1149.22	33.90	0

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 21, LINE 9

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD- JUSTED
H	8036.	201	1025.69	32.02	1
A	6270.	157	984.18	31.37	2
N	7791.	195	2546.52	50.46	3
D	7199.	180	566.87	23.80	5
L	6690.	167	1277.53	35.74	2
I	7968.	199	921.66	30.35	1
N	7634.	191	448.97	21.18	2
G	6854.	171	509.22	22.56	2
*	5568.	139	576.86	24.01	0
O	7708.	193	1399.16	37.40	3
F	6263.	157	701.59	26.48	2
*	5448.	136	1118.81	33.44	1
I	7887.	197	1097.69	33.13	1
T	6564.	164	1039.59	32.24	1
*	6085.	152	668.81	25.86	0
A	6652.	166	684.11	26.15	0
N	6257.	156	736.94	27.14	1
D	6308.	158	518.46	22.76	1

RECORDING SHEET 22, LINE 9

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD- JUSTED
*	5435.	136	765.91	27.67	1
E	7866.	197	2467.82	49.67	8
I	5948.	149	515.81	22.71	3
T	6610.	165	533.78	23.10	4
H	5877.	147	709.57	26.63	1
E	6504.	163	518.84	22.77	0
R	6487.	162	369.89	19.23	2
*	6153.	154	728.39	26.98	1
S	6942.	174	869.94	29.49	2
H	6272.	157	545.01	23.34	2
E	6305.	158	533.73	23.10	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 23, LINE 10

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6188.	155	1129.01	33.60	2
M	7556.	189	861.44	29.35	1
O	7187.	180	613.67	24.77	1
T	6481.	162	885.07	29.75	0
H	6151.	154	479.42	21.89	0
E	6443.	161	732.82	27.07	1
R	6818.	170	905.94	30.09	1
*	6133.	153	993.42	31.51	0
W	6601.	165	992.47	31.50	0
I	5901.	148	454.45	21.31	1
L	7739.	193	464.30	21.54	1
L	6824.	171	457.14	21.38	0
*	6293.	157	1258.22	35.47	1
T	6716.	168	491.04	22.15	2
H	5676.	142	591.59	24.32	2
E	6541.	164	995.80	31.55	2
N	6468.	162	617.56	24.85	2
*	6369.	159	946.37	30.76	0

RECORDING SHEET 24, LINE 10

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
H	7504.	188	942.34	30.69	2
A	5994.	150	562.07	23.70	1
N	7182.	180	652.24	25.53	5
D	6708.	168	723.86	26.90	1
*	5943.	149	1401.49	37.43	0
A	7659.	191	2153.10	46.40	4
*	5836.	146	750.64	27.39	1
T	7114.	178	449.57	21.20	7
I	7088.	177	2716.81	52.12	7
T	7104.	178	1332.84	36.50	4
H	8979.	224	4917.05	70.12	2
E	7043.	176	886.97	29.78	3
*	5949.	149	1193.65	34.54	4
T	7244.	181	1495.64	38.67	3
O	5863.	147	603.99	24.57	2
*	6441.	161	1051.82	32.43	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 25, LINE 10

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
T	6449.	161	486.57	22.05	1
H	5516.	138	590.79	24.30	1
E	6723.	168	645.42	25.40	3
I	6437.	161	1074.37	32.77	1
R	6235.	156	773.26	27.80	1
*	5518.	138	642.24	25.34	2
O	7921.	198	736.82	27.14	2
W	6243.	156	730.47	27.02	1
N	6845.	171	514.91	22.69	1

RECORDING SHEET 26, LINE 11

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6659.	166	1457.90	38.18	1
F	6714.	168	806.42	28.39	5
O	5729.	143	415.57	20.38	6
R	6068.	152	731.56	27.04	5
*	5619.	140	784.60	28.01	1
A	7403.	185	2621.57	51.20	2
I	6469.	162	694.20	26.34	1
D	6678.	167	1186.69	34.44	1
*	5807.	145	874.79	29.57	0
A	7021.	176	2191.25	46.81	2
N	6066.	152	575.82	23.99	1
D	6211.	155	738.40	27.17	1
*	5238.	131	1081.59	32.88	0
H	7878.	197	903.34	30.05	3
E	6634.	166	929.32	30.48	6
L	6448.	161	1233.26	35.11	4
P	8169.	204	1373.72	37.06	3
.	12522.	313	5934.65	77.03	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 27, LINE 11

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	8777.	219	1020.44	31.94	0
*	6433.	161	655.44	25.60	0
A	17356.	434	8377.24	91.52	2
N	11845.	296	6459.86	80.37	2
*	7626.	191	2144.62	46.31	5
E	8911.	223	4396.92	66.30	5
D	9599.	240	2443.22	49.42	4
N	9826.	246	2755.27	52.49	7
A	6760.	169	1262.00	35.52	2
N	7449.	186	1601.62	40.02	8
D	7596.	190	1436.64	37.90	3
*	6278.	157	772.69	27.79	0
A	6278.	157	651.64	25.52	4
N	6151.	154	769.12	27.73	2
D	6183.	155	1031.54	32.11	1
*	5110.	128	715.78	26.75	0

RECORDING SHEET 28, LINE 11

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
O	8237.	206	2622.82	51.21	6
T	6286.	157	848.52	29.12	6
H	6149.	154	436.50	20.89	4
E	6313.	158	773.54	27.81	0
R	7176.	179	841.79	29.01	3
*	6751.	169	1414.87	37.61	2
T	7977.	199	2184.89	46.74	3
A	8648.	216	2453.61	49.53	5
T	8246.	206	1732.67	41.62	0
H	9456.	236	3536.69	59.47	6
E	9912.	248	8695.06	93.24	5
F	10229.	256	4257.10	65.24	5
S	8968.	224	2467.71	49.67	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 29, LINE 12

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6601.	165	1321.72	36.35	1
U	8034.	201	944.77	30.73	1
N	8766.	219	743.37	27.26	1
D	6933.	173	1390.97	37.29	2
E	8708.	218	1050.01	32.40	1
R	6667.	167	726.32	26.95	1
S	8265.	207	1247.73	35.32	3
T	7363.	184	1151.87	33.93	3
A	7176.	179	888.19	29.80	4
N	6842.	171	828.54	28.78	1
D	6235.	156	901.66	30.02	0
*	6097.	152	1429.69	37.81	1
W	6651.	166	1480.70	38.47	5
H	6521.	163	3107.87	55.74	2
E	6308.	158	798.66	28.26	0
N	6806.	170	897.62	29.96	0
*	6471.	162	1006.07	31.71	0
T	6264.	157	1080.79	32.87	0
H	5939.	148	898.55	29.97	0
E	6015.	150	904.33	30.07	0

RECORDING SHEET 30, LINE 12

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	6110.	153	1127.28	33.57	0
F	7112.	178	699.31	26.44	3
A	6977.	174	673.24	25.94	2
T	8088.	202	2883.16	53.69	0
H	7040.	176	1376.40	37.09	4
E	6314.	158	700.52	26.46	4
R	6571.	164	1095.50	33.09	1
S	8629.	216	2120.80	46.05	4
*	6980.	175	1284.35	35.83	3
U	10265.	257	3978.68	63.07	2
D	9676.	242	3943.84	62.80	9
A	9947.	249	3834.72	61.92	2
T	8910.	223	2643.48	51.41	2
H	7872.	197	2815.36	53.05	2
E	8073.	202	1713.99	41.40	9
A	10404.	260	6826.24	82.62	3
C	12314.	308	5860.23	76.55	8
.	9846.	246	3762.97	61.34	7
*	8785.	220	1392.03	37.30	1
*	6619.	165	973.25	31.19	0
T	16583.	415	5441.74	73.76	2

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 31, LINE 13

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	5979.	149	741.05	27.22	1
N	9598.	240	3189.29	56.47	2
E	7209.	180	1735.52	41.65	6
I	7067.	177	1477.82	38.44	3
T	6917.	173	1622.47	40.27	4
H	6049.	151	812.42	28.50	1
E	6079.	152	665.12	25.79	3
R	7002.	175	1401.74	37.43	0
*	6458.	161	1217.24	34.88	0
I	9047.	226	2356.74	48.54	0
T	7390.	185	1630.73	40.38	0
H	9694.	242	4490.52	67.01	2
E	8993.	225	2877.29	53.64	1
T	8930.	223	1772.18	42.09	1
*	6706.	168	688.77	26.24	1
N	10238.	256	6746.49	82.13	2
O	7330.	183	1286.68	35.87	1
R	6873.	172	987.94	31.43	8
*	6430.	161	985.58	31.39	1

RECORDING SHEET 32, LINE 13

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
T	7411.	185	1640.70	40.50	0
H	6347.	159	1340.47	36.61	2
E	8556.	214	2890.89	53.76	9
J	14047.	351	22995.34	151.64	11
*	7998.	200	1201.69	34.66	6
I	8712.	218	2770.91	52.63	1
S	6712.	168	1109.86	33.31	2
*	5501.	138	898.60	29.97	2
H	7824.	196	881.69	29.69	4
A	6297.	157	703.04	26.51	2
N	6594.	165	852.22	29.19	4
D	7130.	178	1730.98	41.60	5
L	7528.	188	3185.36	56.43	4
I	7482.	187	427.04	20.66	1
N	7448.	186	487.46	22.07	0
G	6550.	164	703.23	26.51	2
*	5707.	143	575.52	23.98	0

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS FOR EACH STROKE RECORDED

RECORDING SHEET 33, LINE 13

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
T	7203.	180	714.67	26.73	2
H	5418.	135	879.64	29.65	2
E	6429.	161	583.45	24.15	3
*	5199.	130	1055.82	32.49	1
L	7588.	190	1186.91	34.45	0
E	6507.	163	608.32	24.66	6
A	6878.	172	839.44	28.97	5
T	8554.	214	2951.82	54.33	5
H	6384.	160	723.69	26.90	4
E	6344.	159	749.84	27.38	4
R	6647.	166	1212.04	34.81	5
S	8059.	201	1363.10	36.92	2
,	9204.	230	11361.74	106.59	6

RECORDING SHEET 34, LINE 14

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6964.	174	1584.79	39.80	1
H	9052.	226	3336.11	57.75	4
E	6874.	172	813.42	28.52	9
I	8284.	207	2746.19	52.40	6
T	9900.	248	5813.20	76.24	5
H	8225.	206	3707.33	60.88	5
E	11908.	298	10562.61	102.77	6
G	10164.	254	2026.14	45.01	5
*	7298.	182	1096.64	33.11	0
T	6898.	172	1302.44	36.08	1
H	5903.	148	739.49	27.19	0
E	6006.	150	564.27	23.75	1
M	7008.	175	1752.16	41.85	5
*	6591.	165	1007.67	31.74	0
A	6456.	161	531.89	23.06	1
N	6119.	153	536.72	23.16	1
D	6094.	152	518.37	22.76	1
*	5487.	137	1400.59	37.42	0

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 35, LINE 14

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
U	8482.	212	1617.39	40.21	8
N	9670.	242	3243.08	56.94	5
D	7408.	185	857.01	29.27	6
E	10484.	262	3939.49	62.76	8
T	8910.	223	999.43	31.61	11
S	10403.	260	2766.42	52.59	6
F	11774.	294	6642.72	81.50	2
A	7928.	198	2590.56	50.89	1
N	7248.	181	1418.26	37.65	2
D	6667.	167	901.92	30.03	4
*	6232.	156	1494.96	38.66	1
A	7085.	177	2355.26	48.53	3
N	6143.	154	945.44	30.74	1
D	5874.	147	561.22	23.69	1
*	5439.	136	996.12	31.56	0

RECORDING SHEET 36, LINE 14

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
T	6271.	157	564.17	23.75	1
H	6102.	153	941.49	30.68	1
E	6218.	155	1129.59	33.60	1
N	6908.	173	887.91	29.79	2
*	6716.	168	633.64	25.17	2
D	6426.	161	1194.37	34.55	4
E	8837.	221	1246.37	35.30	1
M	7116.	178	1144.79	33.83	4
A	6048.	151	501.06	22.38	2
N	6581.	165	961.50	31.00	1
D	6381.	160	979.60	31.29	3
*	5925.	148	595.11	24.39	0
T	6465.	162	551.63	23.48	2
H	5942.	149	717.84	26.79	0
E	5925.	148	638.36	25.26	1
Y	6823.	171	941.89	30.69	3

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 37, LINE 15

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
*	6492.	162	669.26	25.87	4
T	6150.	154	792.98	28.16	2
H	6181.	155	649.90	25.49	1
E	5723.	143	746.57	27.32	2
*	6211.	155	1620.55	40.25	0
J	8301.	208	2580.90	50.80	4
A	6533.	163	1049.17	32.39	4
N	7037.	176	847.42	29.11	5
D	8795.	220	4072.31	63.81	10
K	13448.	336	8162.81	90.34	8
U	10402.	260	2083.19	45.64	11
N	10889.	272	2007.97	44.81	1
G	7880.	197	2489.55	49.89	5
*	6146.	154	1107.87	33.28	3
O	7885.	197	1324.61	36.39	4
R	6721.	168	925.87	30.42	6
*	5732.	143	639.16	25.28	2

RECORDING SHEET 38, LINE 15

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. ADJUSTED
T	6488.	162	689.36	26.25	1
H	5671.	142	656.87	25.62	0
E	6010.	150	742.38	27.24	0
*	5673.	142	763.89	27.63	1
F	7396.	185	1519.84	38.98	1
A	7304.	183	888.54	29.80	3
T	8023.	201	950.89	30.83	5
H	8662.	217	2265.69	47.59	3
E	6762.	169	936.74	30.60	2
A	7364.	184	1706.69	41.31	1
D	8304.	208	1267.64	35.60	0
*	6188.	155	980.41	31.31	0
A	6802.	170	794.19	28.18	0
N	6129.	153	724.97	26.92	1
D	6257.	156	463.09	21.51	1

MEAN TIME, VARIANCE, STANDARD DEVIATION, ADJUSTMENTS
FOR EACH STROKE RECORDED

RECORDING SHEET 39, LINE 15

KEY	TOTAL	MEAN	VARIANCE	S.D.	NO. AD-JUSTED
*	5563.	139	1331.82	36.49	1
M	7685.	192	675.16	25.98	2
E	6748.	169	1471.91	38.36	6
A	6929.	173	776.12	27.85	5
T	8232.	206	1912.21	43.72	4
H	9224.	231	5052.99	71.08	4
E	7054.	176	1502.82	38.76	5
A	7450.	186	911.08	30.18	6
D	9914.	248	6895.07	83.03	5
.	8505.	213	1603.73	40.04	3

APPENDIX E

TOTAL TIME FOR GROUPS OF THREE STROKES

FOR ALL THREE-LETTER COMBINATIONS

TO BE USED FOR ANALYSIS

SHOWN FOR EACH SUBJECT

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

APPENDIX F

TOTAL, MEAN, VARIANCE, AND STANDARD DEVIATION

OF EACH THREE-LETTER COMBINATION USED

FOR ENTIRE GROUP OF SUBJECTS

APPENDIX G

MEAN, VARIANCE, AND STANDARD DEVIATION

OBTAINED BY EACH SUBJECT

ON GROUPED STROKES

of

ORDINARY WORD SECTION,

NONSENSE WORD SECTION,

AND ENTIRE COPY

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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TOTAL, MEAN, VARIANCE, AND STANDARD DEVIATION

FOR ALL STROKES RECORDED BY EACH TYPIST

ORDINARY WORD SECTION - 429 RECORDED STROKES

SUBJECT	TOTAL	MEAN	VARIANCE	S.D.
1.1	76070.	177	1200.72	34.65
1.2	79297.	185	3464.00	58.85
1.3	78243.	182	1597.41	39.96
1.4	70601.	165	2210.52	47.01
1.5	84466.	197	916.52	30.27
2.1	82074.	191	1214.92	34.85
2.2	82725.	193	2682.26	51.79
2.3	69807.	163	2229.62	47.21
2.4	75886.	177	1786.68	42.26
2.5	73364.	171	1820.50	42.66
3.1	76974.	179	1284.78	35.84
3.2	74366.	173	1111.64	33.34
3.3	72533.	169	2310.22	48.06
3.4	69611.	162	2482.07	49.82
3.5	78335.	183	2957.03	54.37
4.1	72061.	168	1908.41	43.68
4.2	70249.	164	2490.92	49.90
4.3	71539.	167	2072.47	45.52
4.4	76069.	177	2101.39	45.84
4.5	73092.	170	1800.27	42.42
5.1	68364.	159	2224.87	47.16
5.2	65058.	152	2913.91	53.98
5.3	74462.	174	1813.77	42.58
5.4	71931.	168	3013.93	54.89
5.5	67262.	157	2410.13	49.09
6.1	70203.	164	3671.74	60.59
6.2	67004.	156	3078.75	55.48
6.3	66439.	155	2234.55	47.27
6.4	70497.	164	2590.59	50.89
6.5	74668.	174	1005.02	31.70
7.1	70617.	165	1717.53	41.44
7.2	80095.	187	1350.51	36.74
7.3	74462.	174	2364.34	48.62
7.4	70077.	163	2070.58	45.50
7.5	71658.	167	1408.13	37.52
8.1	68795.	160	828.43	28.78
8.2	77936.	182	2049.33	45.26
8.3	74639.	174	1724.50	41.52
8.4	75673.	176	1585.63	39.81
8.5	73077.	170	995.03	31.54

TOTAL, MEAN, VARIANCE, AND STANDARD DEVIATION

FOR ALL STROKES RECORDED BY EACH TYPIST

NONSENSE WORD SECTION - 210 RECORDED STROKES

SUBJECT	TOTAL	MEAN	VARIANCE	S.D.
1.1	41430.	197	3191.26	56.49
1.2	42198.	201	5347.56	73.12
1.3	42345.	202	4084.24	63.90
1.4	36633.	174	3879.44	62.28
1.5	45555.	217	1812.89	42.57
2.1	41783.	199	1845.77	42.96
2.2	42248.	201	2857.20	53.45
2.3	37033.	176	3312.46	57.55
2.4	42249.	201	4413.42	66.43
2.5	37820.	180	3628.55	60.23
3.1	41650.	198	2316.63	48.13
3.2	40466.	193	2893.80	53.79
3.3	40572.	193	4809.76	69.35
3.4	38111.	181	3550.21	59.58
3.5	42746.	204	6624.53	81.39
4.1	39222.	187	3827.38	61.86
4.2	37816.	180	3807.08	61.70
4.3	38665.	184	5162.14	71.84
4.4	42650.	203	4459.02	66.77
4.5	40458.	193	3769.88	61.39
5.1	36478.	174	4160.58	64.50
5.2	37097.	177	5171.23	71.91
5.3	38737.	184	2861.26	53.49
5.4	39515.	188	3401.99	58.32
5.5	35903.	171	3739.91	61.15
6.1	39196.	187	5350.11	73.14
6.2	36391.	173	5337.90	73.06
6.3	37268.	177	5429.31	73.68
6.4	39394.	188	5236.63	72.36
6.5	39667.	189	2852.52	53.40
7.1	37909.	181	5480.28	74.02
7.2	38844.	185	1430.67	37.82
7.3	42615.	203	5699.96	75.49
7.4	38843.	185	3397.22	58.28
7.5	38638.	184	3348.86	57.86
8.1	37934.	181	3476.39	58.96
8.2	41564.	198	3465.15	58.86
8.3	42982.	205	3043.29	55.16
8.4	39702.	189	3371.26	58.06
8.5	40748.	194	2920.90	54.04

TOTAL, MEAN, VARIANCE, AND STANDARD DEVIATION

FOR ALL STROKES RECORDED BY EACH TYPIST

ENTIRE COPY - 639 RECORDED STROKES

SUBJECT	TOTAL	MEAN	VARIANCE	S.D.
1.1	117500.	184	1942.84	44.07
1.2	121495.	190	4140.21	64.34
1.3	120588.	189	2496.51	49.96
1.4	107234.	168	2780.49	52.73
1.5	130021.	203	1299.70	36.05
2.1	123857.	194	1435.16	37.88
2.2	124973.	196	2755.13	52.48
2.3	106840.	167	2626.45	51.24
2.4	118135.	185	2780.16	52.72
2.5	111184.	174	2432.90	49.32
3.1	118624.	186	1702.75	41.26
3.2	114832.	180	1779.92	42.18
3.3	113105.	177	3260.09	57.09
3.4	107722.	169	2914.58	53.98
3.5	121081.	189	4259.18	65.26
4.1	111283.	174	2617.02	51.15
4.2	108065.	169	2982.27	54.61
4.3	110204.	172	3154.36	56.16
4.4	118719.	186	3022.81	54.98
4.5	113550.	178	2557.08	50.56
5.1	104842.	164	2906.44	53.91
5.2	102155.	160	3793.68	61.59
5.3	113199.	177	2184.19	46.73
5.4	111446.	174	3234.14	56.86
5.5	103165.	161	2891.50	53.77
6.1	109399.	171	4340.07	65.87
6.2	103395.	162	3885.74	62.33
6.3	103707.	162	3397.14	58.28
6.4	109891.	172	3579.57	59.82
6.5	114335.	179	1660.76	40.75
7.1	108526.	170	3009.96	54.86
7.2	118939.	186	1377.51	37.11
7.3	117077.	183	3650.71	60.42
7.4	108920.	170	2609.67	51.08
7.5	110296.	173	2109.36	45.92
8.1	106729.	167	1789.37	42.30
8.2	119500.	187	2572.92	50.72
8.3	117621.	184	2365.75	48.63
8.4	115375.	181	2207.83	46.98
8.5	113825.	178	1751.82	41.85